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PROCEEDINGS

OF THE

LIVERPOOL BIOLOGICAL SOCIETY.

VOL. II.

SESSION 1887—8.

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BIOLOGY

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Errata.

Page 75, lines 10 and 24. Omit *Scrupocellaria ciliatæ*.
Page 114, line 1. For sporophyte (*bis*) read gamophyte (*bis*).

LIVERPOOL BIOLOGICAL SOCIETY.

SESSION II. 1887–8.

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REPORT of the COUNCIL.

The second session of the Liverpool Biological Society has been a lengthy and a very successful one, extending from October, 1887, to June, 1888, and comprising nine meetings, of which eight were held in the evening at University College, while the last was a field meeting at Hilbre Island.

The attendance of Members has been good, and a large number, including many of the Student Members, have taken an active part in the proceedings. The number of communications brought before the Society during the session has been no less than thirty, extending over nearly the whole range of Natural History; and the Council have pleasure in drawing the attention of the Members to the goodly volume of Proceedings, which is now being printed, as the outcome of the sessional activity. The work at the various meetings has been characterized by its eminently practical nature; and the Society may fairly be said to have now gained for itself a place, and to fill a want in Liverpool.

During the session, six Ordinary Members have resigned and ten new Members have been elected; seven Student Members have resigned or left and twenty-six have joined the Society. The number of Members on the roll is now as follows:—

Honorary Members	2
Ordinary Members.....	53
Student Members	52

The following is a summary of the proceedings at the ordinary meetings during the session:—

I. *October 29th*, 1887.

1. Election of the Office-bearers and Council.
2. Inaugural Address by the President, Dr. J. Drysdale, on "The Definition of Life as affected by the Protoplasmic Theory."

II. *November 12th*, 1887.

1. The Foundation and First Year's Work of the Puffin Island Biological Station. By Prof. Herdman, D.Sc.
2. Second Report on the Copepoda of Liverpool Bay. By I. C. Thompson, F.L.S.
3. Report on the Land Mollusca of Puffin Island. By Alfred Leicester.
4. Report on the Higher Crustacea found in Liverpool Bay. By A. O. Walker, J.P., F.L.S.
5. An Actiniarian found in Liverpool Bay. By J. W. Ellis, L.R.C.P.
6. Report on the Polyzoa of Puffin Island. By J. Lomas, Assoc. N.S.S.

III. *December 10th*, 1887.

1. A Report upon the Geology of Puffin Island. By J. W. Gregory, F.G.S., Assistant in the Geological Department of the British Museum.
2. On a Modified Tract of Ectoderm in *Crania anomala*. By Alice Heath.
3. The Terminology of the Reproductive Organs of Plants. By R. J. Harvey Gibson, M.A.

IV. *January 14th*, 1888.

1. On the recommendation of the Council, H.M. King Kalakao was elected an Honorary Member of the Society.
2. General Account of a Biological Visit to the Canary Islands. By I. C. Thompson, F.L.S.

3. Remarks upon the Collection of Invertebrata brought back from the Canary Islands by Mr. Thompson. By R. Hanitsch, Ph.D.

V. *February* 11*th*, 1888.

1. Observations on the Anatomy and Histology of *Limax agrestis*, Part I. By R. Hanitsch, Ph.D.
2. On Alternation of Generations and Specific Nomenclature in *Salpa* and other Animals. By Prof. Herdman, D.Sc.

VI. *March* 9*th*, 1888.

1. Note on the Nectary of *Fritillaria imperialis*. By Hablot J. M. Browne.
2. The Physiology of Protoplasm. By R. J. Harvey Gibson, M.A. Upon which a good discussion ensued.

VII. *April* 13*th*, 1888.

1. The Coleopterous Fauna of Liverpool. By J. W. Ellis, L.R.C.P.
2. Report on the Copepoda of the Maltese Seas collected by Surgeon David Bruce in 1886-7-8. By I. C. Thompson, F.L.S.

VIII. *May* 11*th*, 1888.

1. Observations on the Anatomy and Histology of *Limax agrestis*, Part II. By R. Hanitsch, Ph.D.
2. Notes on the Minute Anatomy of *Doris*. By J. A. Clubb.
3. Observations on the Shape of the Nail Groove. By F. C. Larkin, M.R.C.S., &c.

IX. *June* 9*th*, 1888.

Field Meeting at Hilbre Island.

Election of Prof. Herdman as President for the next session.

INAUGURAL ADDRESS

ON

The DEFINITION OF LIFE as affected by the PROTOPLASMIC THEORY.

By John Drysdale, M.D., F.R.M.S., President.

[Read 29th October, 1887.]

INTRODUCTORY AND HISTORICAL.

Correct definition is the offspring of true knowledge and correct thinking, while it is the parent of farther correct thinking and the advance of knowledge. In no department of science are correct definition and precision in terms of more importance than in that dealing with life. The first question here is whether the word is to be applied to the characteristic actions of living beings, or to an actual or supposed thing presumed to be the cause of those actions. "That life is an entity or substance, material or immaterial, resident in a certain aggregation of matter and the cause both of its organisation and of the characteristic actions which it afterwards performs, is the oldest opinion on the subject," and one that has descended to the present time, expressed by a variety of names, some of which are still in vogue, such as the Vital Spark, the Vital Spirit, and the Vital Principle. This view was hardly questioned till 1780, when John Brown wrote his celebrated "Elementa Medicinæ," wherein the existence of any such entity was denied, and life was said to consist merely in a series of actions performed by organic beings, resulting from the operation of certain exciting powers

attached to matter, on a certain susceptibility of being excited, residing in other matter. "In all states of life," says John Brown, "man and other animals differ from themselves in their dead state, or from any other inanimate matter, in this faculty alone that they can be affected by external agents, as well as by certain functions peculiar to themselves, in such a manner that the phenomena peculiar to the living state can be produced." The great merit of this view is the introduction of a second factor, viz., the co-operation of an external agency, or what is now called the environment, as essential to the very process in which life is stated to consist. The idea of Spontaneity or Spontaneous activity inseparable from the notion of an independent Vital Principle is likewise shut out, and biology is brought within the circle of the true sciences.

The view of life as a process dependent on two factors spread rapidly among physiologists during the generation following John Brown's day, being adopted by Blumenbach, Reil, Cuvier, Bichat, Richerand, Roland, Lawrence and others. Since then it, or at least the idea of life as a process rather than a substantive principle may be said to be almost universally held, and is the foundation of the variously expressed definitions of life as the sum of the actions or functions which will be considered presently. In the meantime, however, we may notice that the word Vitality cannot be used as synonymous with life, for it is only one factor in the actions which constitute life. It is merely a property of a certain collocation of matter we know as "organised," which when acted on by appropriate powers in the environment, is competent to give rise to the actions in which life consists. If, however, vitality is merely a property, resulting from their peculiar chemical composition, of the separate anatomical elementary units

of which an individual organised being is composed, we are compelled at the outset to face the question how such a being can possess the unity and individuality characteristic of living beings; and which is supposed to be accounted for so easily by the possession of an Anima or Vital principle? I must, therefore, state that I agree with those who hold the physical rather than the teleological view of natural phenomena as applicable to living as well as inorganic nature. To illustrate my meaning I quote the following passage from J. Müller's "Physiology" (by Baly, vol. i., p. 19): "The manner in which the elements are combined is not the only difference between organic and inorganic bodies; there is in the living organic matter a principle constantly in action, the operations of which are in accordance with a rational plan, so that the individual parts which it creates in the body are adapted to the design of the whole; and it is this which distinguishes organism. Kant says, 'The reason of the existence of each part of an unorganised being is to be found in itself, while in organised beings the reason of the existence of each part resides in the whole.' This explains why a mere part separated from an organised whole generally does not continue to live; why, in fact, an organised body appears to be one and indivisible." It seems to me that Kant means here the final cause, and that Müller falls into the error of putting final into the place of efficient causes, contrary to the warning of Bacon, and therefore the above quotation is merely a mode of stating certain facts, but explains nothing. The interdependence of parts and the whole has its efficient causes in the properties inherent in the living matter itself which are manifested through the processes of Darwinian Evolution. Since J. Müller wrote the discovery of the cell theory has shown that vitality is inherent in each cell, and

being an incommunicable property could not be dependent on any central influence. A different explanation of the interdependence of the parts and the whole of living beings is therefore given by Schwann, one of the illustrious founders of the cell theory. Schwann states that "The whole organism subsists only by means of the reciprocal action of the single elementary parts," the expression reciprocal action being taken in its widest sense, and as including the preparation by one elementary part of material which another requires for its own nutrition. Thus the majority of the individual cells may be unable to subsist when separated from the whole organism, because it is only while together they can obtain the nutriment and other conditions requisite for continuous life. Therefore "the cause of nutrition and growth resides, not in the organism as a whole, but in the separate elementary parts—the cells. The failure of growth in the case of any particular cell when separated from an organised body, is as slight an objection to this theory, as it is an objection against the independent vitality of a bee that it cannot continue long in existence after being separated from its swarm. The manifestation of the power which resides in the cell depends upon conditions to which it is subject only when in connection with the whole (organism)."* On the general question of the teleological or the physical view of life, I cannot do better than also follow Schwann, who reduces the various opinions with respect to the fundamental powers of organised beings to two, viz., the teleological and the physical. In the former every organ is supposed to "originate with an internal power which models it into comformity with a predominant idea, arranging the molecules in the relation necessary for accomplishing certain purposes held forth by this idea.

* Syd. Soc. Translation, p. 192.

And here, therefore, that which arranges and combines the molecules is a power acting with a definite purpose. * * * The other view is, that the fundamental powers of organised bodies agree essentially with those of inorganic nature,—that they work altogether blindly according to the laws of necessity irrespective of any purpose,—that they are powers which are as much established with the existence of matter as the physical powers are."

It cannot be denied that adaptation to a particular purpose is characteristic of every organism, but the source of this adaptation does not depend upon each organism being developed by the operation of its own power in obedience to that purpose, "but it originates, as in inorganic nature, in the creation of the matter with its blind powers by a rational Being." The evidence of design is quite as great in the inorganic as in the organic world. "We know, for instance, the powers which operate in our planetary system. They operate like all physical powers in accordance with blind laws of necessity, and yet is the planetary system remarkable for its adaptation to a purpose. The ground of this adaptation does not lie in the powers but in Him who has so constituted matter with its powers that in blindly obeying its laws it produces a whole suited to fulfil an intended purpose. In physics all those explanations which were suggested by a teleological view of nature, as the 'horror of a vacuum,' have long since been discarded. But when we speak of the inflammation and suppuration which removes a foreign body, as an effort of the organism to remove the foreign body, or as a proof of the 'autocracy' of the organism, or of the '*vis medicatrix*,' that is as little of an explanation according to the physical view as it would be to say that the motion of the earth around the sun is

an effort of the fundamental power of the planetary system to produce a change of seasons on the planets, or to say that the ebb and flood of the tides are the reaction of the organism of the earth upon the moon. When speaking of a physical explanation of organic phenomena, it is not necessary to understand an explanation by known physical powers, such, for example, as that universal refuge electricity, and the like; but an explanation by means of powers which operate like the physical powers in accordance with strict laws of blind necessity whether they be also to be found in inorganic nature or not. As the elementary materials of organic matter are not different from those of the inorganic kingdom, the source of the organic phenomena can only reside in another combination of these materials."*

The same opinions, supported by very similar arguments, had already been expressed in Fletcher's "Physiology," three years before Schwann's work appeared. The above agrees marvellously with the protoplasmic theory of life, the main proposition of which is that an altered combination of the elements is all sufficient to produce the property of vitality; and that the recognition of this peculiar state of combination may be accepted as an explanation, or at any rate the groundwork for a definition, whether we can understand its nature, or reproduce it in the laboratory, or act upon it at all therein except by destruction. The recognition of the law of gravitation has been of incalculable service in physical science, although the physical cause of gravity remains as yet undiscovered. We are now prepared to enter on a criticism of the definitions of life.

The majority of the earlier followers of John Brown, in discarding the vital principle hypothesis, simply define life

* Cell Theory, p. 186.

in more or less varied phraseology, as the sum of the functions of living beings. According to Cuvier, it is "the sum of the phenomena which have given rise to its formation," thus adding the idea of self-reproduction by its very action, which addition commends itself to our approval; but the definition is still imperfect, as external agency is not recognised, and there is no distinction between the merely physical and the vital actions of living beings. Bichat speaks of life as "the sum of the functions which resist death," the latter part of the sentence being superfluous, or else the whole is tautological and a truism. Cabanis brings into view more the external agencies when he defines life thus: "To live is nothing but to receive impressions and execute the movements which these impressions solicit." This we can hardly admit, as it might apply to inanimate machines. Lawrence, in 1816, represents life as "consisting in the assemblage of all the purposes and functions of organised bodies and the general result of their exercise."

Fletcher comments on a criticism on this definition as follows: "On this, Dr. Mason Good—a name hardly less notorious in physiology than eminent in literature—in ridicule of the doctrine that life has no real existence, which had by this time become rather inconveniently prevalent, facetiously remarks, 'the human frame is hence a barrel organ, possessing a systematic arrangement of parts, played upon by peculiar powers and executing particular pieces or purposes; and life is the music produced by the general assemblage or result of the harmonious actions.' He could not possibly have illustrated the nature of life, consisting as it does in the proper actions of organised beings, more happily. 'We thank thee, Jew, for teaching us that word.'"*

* Fletcher's "Physiology," vol. ii., p. 21.

Sir Charles Morgan, in 1818, defines life as "the sum total of functions which any individual can perform;" but he also adds, that organised beings have no property such as irritability essentially distinct from those of inorganised matter. He is, therefore, the precursor of the more modern physio-chemical school of physiologists which denies that the living matter is in a state of combination *sui generis*.

De Blainville defines life as "the twofold internal "movement of composition and decomposition at once general and continuous." To this Herbert Spencer* objects as being too narrow, inasmuch as it excludes nervous and muscular functions, but I do not think with justice, because the decomposition and recomposition of living matter is involved in these functions just as much as in nutrition. Herbert Spencer also objects to this definition as applying equally to a galvanic battery. To this I likewise demur, because in the latter the chemically acting substances are not renewed in their original form during its very action, as is the case with vital action. So it seems to me this definition comes very near to completeness, but makes too little of the external agencies, and of the distinction between vital and non-vital actions in the individual.

According to G. H. Lewes, "Life is a series of definite and successive changes, both of structure and composition, which take place within an individual without destroying its identity." To this Beale† objects that it applies only to individuals of the higher orders, while life belongs to single white corpuscles or pus corpuscles, and when these grow and multiply by subdivision, what becomes of their identity? And he adds, that such words

* Biology, vol. i., p. 60.

† Todd and Bowman, vol. i., p. 32.

as "individual" and "identity" would destroy the value of any definition. Herbert Spencer objects to the expression "series," for most of the vital functions go on simultaneously. Lewes states in his "Physical Basis of Mind," in 1877, that, if he had not already done so, he would have withdrawn his definition in deference to these criticisms.

Herbert Spencer himself defines life at first as "the co-ordination of actions," but afterwards, as he says, that would equally apply to a description of the solar system, he substitutes for it, after a train of reasoning too long to reproduce here, the following definition.* "The definite combination of heterogeneous changes, both simultaneous and successive, in correspondence with external co-existences and sequences." Upon this Beale remarks† that it does not exclude lifeless machines, and it is doubtful if it includes many things which possess life although apparently quiescent. Also, that Spencer "admits 'the tendency to assume the specific form inherent in all parts of the organism' which is peculiar to living things. He does not, however, attempt to explain the nature of the *tendency*, or why living matter alone exhibits it." I do not of course sympathise with this last sentence of Dr. Beale's, which is inspired by the teleological view and the belief in a vital principle; but my chief objection is that Herbert Spencer's definition does not distinguish between the vital and the non-vital actions of the individual.

To come now to the objections common to all those definitions which describe life as the sum of the functions. What is a function? The term function differs from the term action only as being more comprehensive, and as

* Biology, vol. i., p. 74.

† Todd and Bowman, vol. i., p. 32.

always having reference to some general end:—"the function of respiration, for example, including the actions of many different organs, all of which co-operate in effecting some necessary change in the composition of the fluids. In this view of the matter, then, a function may be defined to be the action, not of an *Organ* but of an Apparatus destined to some specific purpose in the general economy of an organised being."* Now the possession of any apparatus, however simple, implies structure and the manifestation of various physical and chemical actions to which the term vital could never be applied. For example, in a vertebrate animal with motor, circulating and digestive apparatus, the resistance and support of the skeleton and the tenacity and elasticity of the blood-vessels are physical attributes, but the formation and maintenance of these and all other tissues are vital. The first stages of the digestion of food are mere chemical action, but the secretion of the digestive ferments and juices, the absorption of the chyme by the villi, and the conversion of it into blood are vital. The perception of stimuli and discharge of *vis nervosa* are vital, but the transmission of it through the nerves is probably physical. The whole quantitative relations of the transformation of force in living beings are exactly the same as in non-living things. From this it is evident that the functions are composed of both living and non-living actions.

Besides this, we have seen that the second factor of the production of life, according to John Brown, includes not only "external agents," but "certain functions peculiar to themselves" (acting as stimuli to other parts), these together comprising what is now termed the environment.

The environment is always non-living, and a portion of it is a part of each living individual. Therefore we

* Fletcher's "Physiology," vol. ii., p. 5.

may say there is no individual, however low in the scale, which has not something physical and chemical in the "sum of its functions" besides the distinctively vital. "In every living thing," says Beale, "there are physio-chemical actions which also occur out of the body, and vital actions."* For these reasons the definition of life as the sum of the functions of living beings cannot be accepted as a definition of life in the abstract. It is merely a definition in a collective or general sense of the life of particular individuals or species. A similar meaning seems to be implied in the statement of Virchow:† "Every animal presents itself as the sum of vital unities, any one of which manifests all the characteristics of life." And the above give point to Beale's remark that "the words individual and identity would destroy any definition." That it applies to individuals, and does not discriminate between living and non-living action is also, I think, a fatal objection to Herbert Spencer's definition of life.

To define life in the abstract, we must be able to separate what is vital from what is non-vital in functions to which both kinds of action contribute. Is this possible in the present position of biological science?

Does anatomy, human or comparative, enable us to point to one or more material anatomical elements whose properties are distinctly vital, as contrasted with the physical and chemical properties of inanimate bodies? To this the answer is in the affirmative, for if we trace back the phylogenic stem of animate nature to its lowest and simplest origin, we find as it were the non-living dissected away and separated from the living on a grand scale, and with the infinity of detail and variety usual in

* Protoplasm, 1874, p. 74.

† Cellular Pathology, p. 13.

nature. We find that the apparatus with which the essential functions are performed by the highest animals become gradually simpler and less concentrated, while the corresponding living matter is less differentiated for the several functions, which latter are gradually diffused more and more through the whole individual till finally all trace of apparatus and even visible structure disappears, leaving a formless mass of semi-fluid nitrogenous matter, such as *Amœba,* exhibiting the essentially vital functions—now reduced to actions—of respiration, movement (automatic and irritable), assimilation, growth, secretion and reproduction. It is unnecessary here to speak of sensation, thought and will, as these are not essential to life, seeing that they are absent in vegetables.

From the *Amœba* we have learned much towards discriminating the anatomical seat of vitality, but not yet the whole protoplasmic theory of life. For although it was perceived that in lowly and imperfectly organised beings the essential vital functions could take place; and seeing that for the complete differentiation of kinds of living matter and the building up of higher organisms, more or less rigid structural organs and apparatus are necessary, yet vitality might still reside in these organs and apparatus as a whole, while the protoplasm, corresponding to the *Amœba's* whole mass, acted as the embryonal formative element only. This is probably very much the opinion of many biologists still, even since the grand generalisation of Beale, in 1860, that vitality resides in one anatomical element alone in all animated beings, not only in the stage of the ovum but all through life.

It is impossible, and it would be superfluous otherwise, here, to go into the historical development for the proofs of this doctrine, to which I hereby profess unqualified assent. I must refer to Dr. Beale's works, more especially

to the little book called "Bioplasm," which should be studied exhaustively by all biologists, but more particularly those belonging to the medical profession, for it keeps ever in the foreground the truly vital part of the functions of living beings; whereas the bulk of most of the very bulky text-books on physiology is taken up with the quite subordinate departments belonging to chemistry and physics.

Let me here call to mind the chief points of the protoplasmic theory, in order that we may discuss its bearing on the definition of life. According to Beale, the sole living matter, called by him germinal matter or bioplasm, is generically one, although specifically capable of infinite variety. In its physical aspect it is transparent and colourless, and as far as can be detected by the highest powers, perfectly structureless at every period of its existence. In consistence it is semi-fluid, slightly viscid like gum or syrup, colloid, capable of imbibition to a large extent with water, but not soluble or diffusible. No difference can be detected by the microscope between the germinal matter of the lowest epithelial scale and that from which the nerve-cells of man's brain are evolved. From these physical characters, common to all bioplasm, it appears precisely the same in all living beings, although it may display an almost infinite variety of specific powers in the different simple organisms, and in the different organs of the more complicated organisms which it animates; nevertheless certain differences in composition of the varieties of living matter have been inferred from differences detected by analysis of the chemical proximate principles found in it after death.

The bioplasm, or one living matter of Beale, corresponds to the following histological elements of other authors, viz.:—The viscid nitrogenous substance within the pri-

mordial utricle, called by Von Mohl, protoplasm; the primordial utricle itself in Nægeli's sense of the term, viz. the layer of protoplasm next to the cell-wall; the transparent semi-fluid matter in the spaces and intervals between the threads and walls of those spaces formed by the so-called vacuolation of protoplasmic masses; the nucleus and nucleoli of vegetable cells; chlorophyll and similar bodies which grow by subdivision or form starch (Strasburger); the greater part of the sarcode of the Monera, Rhizopoda, and other low organisms; the so-called nucleus of the secreting cells, and of the tissues of higher animals and many plants; the white blood corpuscles, pus corpuscles, and other naked wandering masses of living matter; the nuclei of the cells of the grey matter of the brain, spinal marrow and ganglia, and the nuclei of nerve-fibre.

On the other hand, the term germinal or living matter, or bioplasm, or protoplasm, if that is to be accepted as the universal name of the ideal living matter, can never be correctly applied to the following substances, although this error has been committed in respect to some of them, viz.:—The cell-wall of plants and animals, however delicate and gelatinous; the threads* or filaments and

* More recent observations show that certain parts of the vegetable cell, which may be described as bands and threads really belong to the living matter. Hanstein describes the different parts of the primordial utricle as connected along and across the inner space by bands and threads of the same nature as itself. He directs attention to the continual movements going on in the living cell, not only the streams and currents of the liquid parts, but of the protoplasm itself. "The whole system of all these segments is in the act of constant pushing and change of position, the bands glide hither and thither, vanish into the utricle which surrounds them, and new ones arise from it; the primordial utricle itself displaces its parts and exchanges substance with the bands and glides, not only partially but as a whole, along the walls of its containing structure. Nothing appears stable as regards form and mass. Even the outline and the inner arrangement of the nucleus, which is pro-

walls of the vacuoles within protoplasmic masses or cells; the wall of the primordial utricle; the true fibrous, connective, elastic, bony or other tissues generally included

bably the most stable part of the cell, does not remain always the same. Nevertheless the shape and individuality of the whole remains permanently secured."—*Züge aus der Biologie des Protoplasmas*, p. 4.

"As the mollusk not only builds itself in its shell but moves itself in it, so the protoplasm-body in its cell wall. Neither the streams in the bands, nor the nucleus, nor the primordial utricle are alone the seat and cause of the movement. The whole protoplasm-body, which is not a 'substance' but an 'organism,' moves itself in all its parts, at one time all at once, at another alternately, as a single *Amœba*-like, animated, individual being."—Op. cit., p. 16.

These protoplasmic movements and extension of processes are, however, far from uniform in extent and intensity and may be apparently absent for long.

It is probable that by means of such bands and processes a connection between the protoplasm of the different cells of plants may be established and maintained. For it has been felt as a difficulty how the myriads of cells totally separated from each other by dead cell walls, of which a plant is said to consist, could co-operate so as to assume by growth and limitation of growth, the complete predetermined form and otherwise act as a whole. In 1883, Mr. Walter Gardiner, after adducing the evidence from Sachs, Hanstein, and Russow, of the existence of sieve-like perforations in the contiguous walls of different cells, gives his own observations of the actual extension of fine protoplasmic filaments through the perforations in the plant cells of several different species and concludes that it is extremely probable that "not only is continuity of protoplasm established from cell to cell in these instances, but that the phenomenon is one of much wider, if not of universal occurrence."—*Nature*, 26th February, 1885.

In 1884, Schaarschmidt, in papers containing the complete history of the subject, and much additional observation of his own, asserts the complete doctrine of continuity of protoplasm in all plant-cells. He concludes that—1st. The protoplasts of all the tissues in united cells are in direct communication by means of finely attenuated protoplasmic threads. 2nd. The connective threads traverse the pit-closing membrane (which is of a sieve-plate structure), while in unpitted cells they traverse directly the cell-wall. By these threads is the communication between the connective processes which occupy the pit-cavity from both sides directly established.

The protoplasts of the plants (composed from tissues) form a higher unity—one synplast.—*Nature*, 29th January, 1885.

The view of some vegetable physiologists that the cytoplasma consists of a

among the living parts of animals; even the proper contractile fibre of the muscles; the radiating fibre of the caudate nerve-cells and the outer coat of those cells, besides the nerve-fibres in general; the hard parts of epithelial cells, and all liquid secretions; the cilia; the tissue of cuticle, hair, nails, horn, and all analogous parts in plants; the granules and microsomata in the protoplasm of plant-cells; all colouring matters; all pabulum, including the fluid parts of the blood, lymph and chyle, and corresponding matters in plants such as cell-sap; lastly, in general to all structure with any degree of rigidity, all gases, all liquids, all substances capable of solution, all crystalloids, all simple elements, and all binary and ternary chemical compounds.

ON THE CHEMICAL STATE OF PROTOPLASM.

According to Dr. Beale, when the life of a mass of bioplasm is suddenly cut short, four classes of bodies cognisable by chemical tests are found, viz.:—(1) fibrin, which separates spontaneously soon after death; (2) various proteid or albuminous substances; (3) fatty matters, and (4) salts. These do not exist as such in the living matter or bioplasm, but as the latter dies it splits up into these four classes of compounds. No method as yet exists enabling us to prove that protein or albumen, or any of the proximate principles, exist in the living matter as such. If we attempt to analyse living matter

frame-work or network is opposed by the more recent observers Berthold and Schwartz, who maintain that the appearances described by Fromman, Schmitz, Strasburger and others were really *post mortem* and depended on coagulation produced by reagents. Schwarz (Cohn's *Beiträge*, 1887, p. 136) concludes that no preformed network or frame-work exists in the cytoplasma, although a portion of the same may form itself into threads and bands and be reabsorbed into the mass as was previously stated by Hanstein.

it becomes changed, and we examine not the actual living growing matter itself, but the substances which result from its death. We are compelled to conclude that the living matter is composed of the sum of the elements found immediately after death, combined or associated in some unknown manner peculiar to itself. In the words of Dr. Beale, "It seems probable that during this temporary living state the elements do not exist in a state of ordinary chemical combination at all. These ordinary attractions or affinities seem to be suspended for the time."

A similar view had already been set forth a quarter of a century before, in Fletcher's "Physiology," where it is stated (p. 133), that none of the proximate principles are contained in the living matter, "but only the same elements as these compounds contain associated and held together by a power quite distinct from common chemical affinity in a state of combination peculiar to living matter; and that it is only at the instant of the cessation of the vitality of each organised tissue that these compounds are formed—at that instant when the power called chemical affinity succeeds another power, which may be called vital affinity, and by which it had been previously superseded, and common chemical compounds are all that is left of that organised mass into which the elements had been before associated." He is careful to add, that this "power called vital affinity" is not dependent on any essence or force added to the living matter, but is simply the property of matter in that state of combination, just as sweetness is of sugar.

We have seen also that Schwann, in 1839, held that "the source of the organic phenomena can only reside in another combination of the materials." Herbert Spencer also is compelled to frame the hypothesis of an ulterior

state of combination in the living matter, which he terms "physiological units," in order to account for vital phenomena.* It is true he attempts to restrict the function of these to the plastic powers of life, on which depend heredity and the development of individuals and species. But he is obliged to admit that those "physiological units," which are molecules one degree higher in complexity than those molecules of nitrogenous colloidal substance into which organic matter is resolvable must first form an aggregate able "to unite the nitrogenous molecules it meets with, into complex molecules like those of which it is composed" (vol. i., p. 11). That is to say, an aggregate possessing the faculty of combining heterogeneous compounds (pabulum) into matter like itself—growth, in fact—the very thing possessed by living matter and by no other substance in the world. Hence Herbert Spencer's physiological units merely mean the peculiar state of combination of the elements fundamentally essential to all living matter or protoplasm, although the latter may have, in addition, innumerable specific varieties with corresponding powers, derived from complex combinations of the units.

The truth is, that the cardinal distinction between the action of living and non-living matter in a chemical point

* If then, this organic polarity can be possessed neither by the chemical units nor the morphological units we must conceive it as possessed by certain intermediate units which we may term *physiological*. There seems no alternative but to suppose that the chemical units combine into units immensely more complex than themselves, complex as they are; and that in each organism the physiological units produced by this further compounding of highly compound atoms have a more or less distinctive character. We must conclude that in each case some slight difference of composition in these units, leading to some slight difference in their mutual play of forces, produces a difference in the form which the aggregate of them assumes."—*Biology*, 1884, I., p. 183.

of view, as the word is ordinarily understood, is simply this: that in all chemical combination, double decomposition and recombination with formation of a third substance into which both factors enter in exact proportions are the rule; while here, when a chemical substance—pabulum (generally a complex compound)—is placed in contact with living matter, the latter is not decomposed, but on the contrary grows, while the pabulum is decomposed and its elements incorporated with the living matter as far as the latter requires. This faculty of renewing itself from heterogeneous matter has no parallel in the chemistry of non-living bodies, and is the distinguishing mark of protoplasm or living matter. It is true that the chemical ferments and catalytic agents are not decomposed in the act of inducing chemical changes, but neither do they grow thereby as does the living matter. For these reasons it is obvious that no knowledge of the chemical relations of any substance with the proteids or any proximate principles found in protoplasm after death, can afford the slightest clue to what may be its action during life, except perhaps coarsely destructive.*

* As a test of a difference of chemical state between protoplasm in the living state and the same when dead, Dr. Loew has noticed that a weak alkaline solution of nitrate of silver is reduced by the living but not by the dead protoplasm. *Spirogyra*, one of the lower Algæ, acts in this way, reducing the silver salt when the protoplasm is living but not after its death.—*Nature*, 8th October, 1885.

Hanstein (*Das Protoplasma*, p. 243) states that living vegetable cells placed in watery solutions of various colouring matters allow the waters to diffuse through both the cell wall and the primordial utricle, but the colouring matter is stopped by the latter which consists of protoplasm as long as it is alive, while after death it is freely penetrated by many kinds of these same colouring matters. This shows palpably that in the act of death a change in the molecular constitution or arrangement of the protoplasm has taken place. Strasburger (*Theilungs vorgang der Zellkerne*, p. 4) simply states that "the

protoplasm consists of active albumen and ceases to be protoplasm as soon as the albumen has passed from the active to the inactive state." This restricts the word protoplasm to the living state, and confirms the need of a specific name for the mass into which protoplasm is resolvable at death. The expressions active and inactive albumen are ambiguous, and the above author by no means states or implies that "inactive albumen" can again become "active" or living in any other way than as pabulum through other living matter. Sachs expresses the opinion of all physiologists who reject the mysterious vital principle, when he says that the matter of the organism must completely condition the form and that the protoplasm of the leaf, shoot, root and flower of a plant must be qualitatively and quantitatively as distinct as their morphological organism, although he has no more than any one else been able to demonstrate chemically that difference.

Berthold (*Protoplasma mcckanik*, 1887) rejects the prominence given to albumen or any other single proteid or proximate principle, and agrees with Baumann that we just as well say that water was the essential constituent; for chemical analysis always shows extreme complexity in the proteids and other matters into which protoplasm is resolved after death, and the albumen of the laboratory shows no more properties of life than water itself. The constituents found in protoplasm, both elemental and proximate are no doubt combined into an essential whole, although as yet chemistry "has hardly lifted in a few places the veil which conceals from us the knowledge of that state" (p. 75). Besides, "doubtless not all organisms are alike in this respect, and many substances are necessary for one which can be done without by another, and the same holds good in the different stages of the same organism" (p. 75). F. Schwartz, in his *Morphologische und Chemische Zusammensetzung des Protoplasmas*, in Cohn's *Beiträge*, 1887, says (p. 8) that all chemical researches on protoplasm deal as yet only with it in its dead state, and that this is a defect to be regretted, but as yet without remedy, as far as he can see. Still it is progress when we can point out differences in the dead contents of different kinds of protoplasm, as we have a right to infer from these, differences in the living state. He states (p. 9) that in the cytoplasma only one protein stuff can be detected; in the chlorophyll bodies two; and in the nuclei five different such bodies are found. He infers, therefore, that the latter are more complex and highly organised than the former parts of the vegetable cell. These facts, and many more of the same nature which might be adduced, should be, I think, always borne in mind, for by the continual insistance by Dr. Beale on the apparent uniformity of all kinds of protoplasm while their properties are so different, a kind of support is tacitly insinuated for the hypothetical vital principle which he is endeavouring to bring back into Biology.

VITAL PROPERTIES OF PROTOPLASM.

Dr. Beale thus sums up the chief vital actions of protoplasm: "It alone is concerned in development and the production of those materials which ultimately take the form of tissue, secretion, or deposit, as the case may be; and of producing matter like itself out of matters differing materially in composition, properties and powers. Upon it all growth, multiplication, conversion, and in short, life depend. By its agency every kind of living thing is made, and without it, as far as is known, no living thing ever has been made or can be made at this time, or ever will be made." "The difference between germinal or living matter, or bioplasm, and the *pabulum* which nourishes it on the one hand and the formed material on the other hand is, I believe, absolute. The pabulum does not shade by imperceptible gradations into the living matter, and the latter into the formed material" (Bioplasm, p. 185). Thus as all formed material is dead, the formation of all tissues and secretions, and all work done, implies the death of a corresponding amount of protoplasm, or as Beale expresses it, the protoplasm of this or that special kind *dies into* this or that tissue or secretion—not only so, but "every action in every animal, from the first moment of its existence to the last, marks the death of bioplasm and is a consequence of it. Every work performed by man, every thought expressed by him, is a consequence of bioplasm passing from the state of life—ceasing in fact to be bioplasm—and becoming non-living matter with totally different properties" (p. 10).

Here then is a basis for the definition of life as simply "the consumption of protoplasm." But as the continual supply of fresh material is required, and as "every particle

that is to become tissue must first pass through the living state," we must provide for growth and renewal in the definition, which might stand thus: "Life is the consumption and regeneration of protoplasm." This is not the definition of Dr. Beale, nor do I think it sufficient, as it does not bring in the second factor in life considered as an action. For be it remembered life is not a static state, but a process or action implying continual changes. The faculty of undergoing these special changes is *vitality*, but not yet life till the second factor comes into operation and takes its part in inducing those special changes in which life consists. According to Dr. Beale (Bioplasm, p. 60), "living organisms as well as every particle of living matter are incessantly undergoing change* in every part, but the rate of change varies marvellously in different cases. Some materials passing through the stages of living or *forming* matter, *formed* matter and products of disintegration in a few minutes, while others last for many years as formed structure, and perform an important office during the whole time." There is we know a resting and an active stage of living matter, and in some forms, as for example the seeds of plants, the vitality may be prolonged for an indefinite time with a minimum of change, but even in these some small amount of change does go on.

The second factor contributing to those changes is the contact with the environment, and this therefore constitutes an essential part in the process of life. Considered in reference to protoplasm, the environment may be divided into Pabulum, Conditions and Stimuli. The first of these is fully recognised by Dr. Beale, when he says:

* According to Berthold (Op. cit., 1886, p. 8), "the protoplasm is in a state of continual change, and its composition is being perpetually altered as long as life lasts."

"All that is essential in the cell or elementary part is matter that *is* in the living state, germinal matter, and matter that *was* in the living state, formed material; with these is usually associated a certain proportion of matter about to become living, the pabulum or food." He lays the greatest stress on the abundance of access or privation of the pabulum in the causation of changes of nutrition in health and disease, but takes little account of the two other departments of the environment. The primary importance and in fact essentiality of pabulum cannot of course be diminished in the smallest degree; and the very name of pabulum shows the very peculiar and exceptional relation subsisting between protoplasm and ordinary chemical compounds; and the radical difference which exists between it and that which obtains between two non-living compounds which react chemically with each other. No one talks of, say, alkalies forming the food of acids, or implies in any way that one of these agents can grow in mass by decomposing and appropriating what it requires of the elements of the other, without being at the same time decomposed.

The conditions and the stimuli are likewise essential to the process of life. Under *conditions* we must include chiefly heat, moisture, and the maintenance of the proper state of osmosis. Heat we must place in the category of conditions, for we have no reason to suppose that external heat is transformed and used in vital processes, but rather that it acts as temperature in bringing about and maintaining a state of molecular velocities and repulsion necessary for the protoplasmic and chemical processes of the living body, as it is for many chemical reactions. It is true we find in Hermann's "Physiology," one passage which states, that part of the kinetic energy used in reducing the carbonic acid and ammonia of their food is

derived from external heat, and therefore that plants cool the bodies in their vicinity; but no experimental proof is given, nor is there any reference there or elsewhere to any such proof. So I think we must in the meantime confine the action of external heat to the maintenance of temperature, and refer the source of the whole kinetic energy required to light and those oxidative processes which also take place in plants. External heat is therefore only a condition of life, and does not supply the kinetic energy required for its functions. Water is also a condition, for it is not (except in chlorophyll bearing organisms) decomposed and used as pabulum. It is essential to maintain the requisite mobility of the protoplasm, which, though not soluble or diffusible, is capable of imbibition of such a large quantity of water that it has the mobility of a liquid, or rather, as Berthold maintains, the physical properties of an emulsion. The maintenance of the requisite osmotic state is likewise a necessary condition of the environment. In many vegetable cells the protoplasmic part of the contents, which is always alkaline, is surrounded with faintly acid non-living cell-sap. During life these are kept in equilibrium, but any cause of diffusion of the alkaline contents produces decomposition and death of the protoplasm. Even distilled water may act thus prejudicially on the bioplasts of animals, and accordingly in experiments on animals the circulation cannot be kept up with pure water, but a weak solution of common salt is requisite.

The third division of the environment consists of the stimuli, which act as liberators of vital action, and thus their effect appears out of proportion to their quantity. The stimuli consist of the active forces and of chemical substances. The forces thus acting are mechanical force, sound, light, electricity, *vis nervosa* and heat. The

chemical stimuli enter into the protoplasm of the tissues, blood, nerve-centres, secreting cells, &c., and exalt, depress, or modify vital action by disturbing the vital-molecular changes; not being adapted in quantity or quality to renew the protoplasm as pabulum, any increased evolution of kinetic energy they excite must be supplied by wasting or consumption of protoplasm—hence fatigue, till the latter is renewed from fresh pabulum. As examples of extreme minuteness of the needful quantity among the forces may be noted that of mechanical force in the sense of tact, hearing and sight; and among the chemical stimuli those of taste and smell in animals; and in vegetables the various solutions of salts which excite the protoplasmic contractions of the drosera, &c. For the interaction of the environment in its capacity of stimulus is quite as essential to vegetable as to animal life, although not so conspicuous. This class—the stimuli—comprises all poisons and medicines, and material agents acting otherwise than as pabulum or simple conditions.

These three divisions are set forth separately here for convenience, but in nature there is no such separation, and they are all three essential to the performance of every vital act. Some physiologists, however, have laid stress on one to the exclusion almost of the others. For instance, as above said, Dr. Beale puts the pabulum completely in the foreground, and scarcely allows the existence of the stimuli—in fact he asserts the spontaneity of most vital actions. On the other hand, Fletcher, following John Brown, places the stimuli almost as much in the foreground as Beale does the pabulum, for he denies spontaneity *in toto*, and defines life as "irritation," or the action of stimuli upon irritability. The word irritability being explained as that used by Glisson, and synonymous with vitality as a whole, and not restricted, as by some

recent physiologists, to the faculty of evolving actual energy—on the application of a stimulus—a faculty, one would think, equally within the power of a non-living machine. Others again vaguely and indiscriminately speak of the whole relations of the environment as conditions. These discrepancies may be partly accounted for by the fact, as above said, that all functions of the environment must be in operation in every vital, and also that many of the agents of which the environment is composed must act more or less in two or in all three of these capacities. Heat, for example, besides being always an essential condition acts as a stimulus when in excess, hurrying on vital action till exhaustion and death take place. Oxygen, which may be termed pabulum of force, because it furnishes potential energy in quantitative relation to the kinetic energy evolved in the bodily functions, is also a stimulus which in excess hurries on vital action to disease and death. Material pabulum itself is a stimulus. We may thus go through the greater part of the elements of the environment and show that stimuli are essential externally or internally as regards a complicated organism, though always externally as regards the protoplasm. We thus learn to be cautious in attributing spontaneity to any living action, but rather to appreciate the scientific reserve of those physiologists who speak of protoplasmic movements or functions of which the immediate exciting cause is not obvious, as due to stimuli or agencies as yet unknown, rather than conclude at once that they are spontaneous.

We have now reached a point where we can give a complete definition of life in the abstract, viz., as "the consumption and regeneration of protoplasm in co-operation with external conditions, pabulum and stimuli." Or

more concisely in the words of Fletcher:* "Life is the sum of the actions of organised beings, resulting directly from their vitality acted on by" [pabulum, conditions and stimuli]. Observe the word *directly*, for it is this which separates the non-vital from the vital functions, and makes this a definition of life in the abstract; vitality and its anatomical seat having been previously defined. With the same proviso of a previous explanation of the nature of protoplasm, I think the definition may be further simplified as follows: "Life is the interaction of protoplasm with the environment."

Now if this is a correct description of the cardinal fact in every vital act, it is not only a complete definition of life in the abstract, but it may be held to be a sufficient explanation of the nature of life to mark off biology to its place in the circle of the physical sciences in the wide sense. For, after all, what is an explanation? The explanation of any fact in nature is simply showing that it is the necessary outcome of other facts and laws known to us already in nature by observation and experience. And when we push the same question to these last and beyond them we very soon come to a point where no answer can be given. Nevertheless within certain limits the reference of any fact to a wider series of facts and laws is to all intents and purposes a sufficient explanation. I have given above the example of Newton in explaining the motions and positions of the heavenly bodies by the hypothesis of the extension of the terrestrial law of gravitation to all space. As this has been found to fit all the facts, it is universally received as a true explanation, although the physical cause of gravity was not discovered by Newton, and remains undiscovered still. In like manner may we not consider it a sufficient explanation

* Rudiments of Physiology, p. 34.

when we can trace back life to its essential physical basis, which we can see and handle, and find out that nothing ponderable escapes, nor is any force transferred or transformed from it at death; and, in fact, that in it nothing is discernible at death but a re-arrangement of chemical compounds? A substance likewise which we can test as to its proximate and ultimate elements, although we cannot put these together again, nor form an intelligible representation as to how they are combined in the living state so as to re-act as they do on contact with the environment? I apprehend it is; and if we relegate to biology all those facts which are observed on living matter and those only, excluding rigidly every physical and chemical action on the non-living tissues and fluids, as well as on the proteids constituting the proximate principles found in protoplasm after death. Thus all the reactions of different kinds of matter from the simplest binary combinations up to the most complex so called organic compounds cognisable in the laboratory belong to chemistry as at present understood; while these reactions between protoplasm and the environment, not cognisable in the laboratory, except by their results, may be held to constitute physiology and bear the name of protoplasmic.* As we cannot explain why the different elements behave towards each other as

* The term organic chemistry has been for long applied to that which deals with compounds synthetically formed through life, and which we could not set together from their elements in the laboratory. But since the formation of urea from the elements in 1828, so many so-called organic compounds can now be made in the laboratory that the term organic may be said to have lost its significance; and it is time to divide all actions between the atoms or molecules of different bodies into chemical and protoplasmic as suggested above. Of course the word organised should not be used as synonymous with organic in the old chemical sense. Nevertheless, Hanstein (p. 8) speaks of starch as "organised" when arranging it among the metaplasmata, or materials formed by protoplasm. Such careless use of words induces endless confusion.

they do in ordinary chemical action, but are obliged to refer the cause to their inherent specific properties, why should we expect to explain the very special action of the very peculiar and complex compound protoplasm? To invoke the hypothesis of a spiritual vital principle which multiplies without limit apparently out of nothing on all growth of protoplasm and vanishes into nothingness on its death, and of whose existence we have no proof except the phenomena which it is called upon to explain, is merely to shut out biology from the true sciences. To refer vitality to a special form of force belonging to the correlated circle of the physical forces, shows a complete misunderstanding of the meaning of the word force. Probably all that shall ever be accomplished in the way of explanation of the possession of vitality by a mere material compound is the tracing back in a complete chain, the steps whereby new properties are developed by complexity of chemical composition and molecular grouping. In the end, however, the potentiality of all these must have lain in the specific, inherent, primary properties of matter which can never be explained.

As examples of the confusion induced by want of sufficient precision in our definition of terms, I may notice the expression "life without organisation," applied by Huxley to the Rhizopoda. If we carefully restrict the word organisation, as proposed by Fletcher, to the process of organising, and the word organism to the result of that process, and at the same time fix exactly what we mean under the last word, we shall escape the ambiguity and confusion into which many have fallen in respect to the above expressions, and from the futile strife whether life is the result of organisation, or organisation the result of life. On the protoplasmic theory the expression life without organisation cannot possibly be correct, for vitality

depends on the result of organisation, viz. organism. Huxley uses the word organisation in the double sense both of the process and the result, and in addition really means structure more or less rigid and palpable to the senses. In defining "organism or organic structure," as the result of the process of organisation, Fletcher also appears to be ambiguous; but he explains, on the next page, the use of the word structure as a general term for the material presentment of organised beings, and under that word he includes the *composition* of the living matter. According to this, a mass of protoplasm without any visible structure is still to be described as "organism," and to have undergone the *process* called "organisation." In the same sense, Bastian speaks of protoplasm as possessing "molecular organisation." He should have said "organism," or molecularly organised matter, if the above limitation of organisation to the process is to be adopted. In fact the use of the word "organised," as synonymous with vital or living,* is so nearly universal

* The word organised can only apply with propriety to a peculiar combination of the elements of the protoplasm as a whole, and not to a mere changed molecular grouping, such as allotropism, of the proteid or other proximate principles, into which it is resolved at death as asserted or implied by Nægeli and Pfeffers. Nor can the physical movements or changes caused by the molecular state of the protoplasm, as, for example, a colloid capable of a distinctly limited degree of imbibition with water be called vital or organised. As said by Strasburger, all organised substance is colloid, but not all colloids are therefore organised. Berthold (1886) has extended considerably our knowledge of the important part played by the physical properties of the protoplasm as an emulsion in growth and sub-division; but even Dr. Beale—a vital principlist—admits that in the smallest mass of living matter something physical belongs to its functions just in the higher creatures with visible structure. And Berthold—a non-vital principlist—after urging as far as possible the physical actions derived from the molecular grouping of the protoplasm, denies that therein lie the true characteristics of the living matter: these lie in the "peculiar course of the interactions of the totality of its matter and forces" (p. 81). These remarks suggest a further limitation of Bastian's expression

that we must accept it as proper, and hence the word organised must apply to protoplasm. Therefore, Huxley's expression ought to have been, "Life without more or less rigid visible structure." The expression, "Life results from organisation," ought to be "Vitality results from organism." It is true that all organism is the result of a previous process of organisation, while we only know this latter as the work of a pre-existing organism, so that to discuss which was first seems as vain and futile as to raise the old question, Which was first, the egg or the bird? Suffice it to say now, we know of no organism which did not originate from a pre-existing organism through the process of organisation, and no passage of non-living matter into living matter except through the growth of already living matter. Science affords no data for any, even plausible, conjectures as to any natural process to account for the origin of living matter on our planet. I think we must be content to follow Darwin,* in seeing in it the direct interference of the hand of the Creator.

Another expression, arising from speculations on the origin of life, which I cannot admit to be correct, is "organisable protoplasm," used by Gavarret and Herbert Spencer. Protoplasm cannot be protoplasm till it is organised, and all pabulum is organisable already.

With respect to the word protoplasm, the time seems to be now come when it can be said to be universally adopted as synonymous with the living matter. In that case biologists should agree to restrict the word rigidly to the ideal living matter alone, and never apply it to a variety

molecular organisation which might be called atomic rather than molecular. At any rate the words organisation and organism must apply to the composition of the new molecules constituting protoplasm, and not to a mere altered grouping of any proteid molecules known in the laboratory.

* "Origin of Species," 6th Ed. p. 429.

of the contents of the cells some of which are not living, as has been done. This restriction would obviate several sources of confusion and incorrect nomenclature. The expression "living protoplasm" would be seen to be useless and tautological; and at the same time that of dead protoplasm becomes incorrect and contradictory. This reveals a practical want, viz. a word to describe the product of the rapid death of protoplasm.* For want of precision on these points, Mr. Huxley fell into error, and mystified the public, in his "Physical Basis of Life," published in 1869, by speaking of mutton, bread, lobster, and other things, as ready-made protoplasm. In consequence of this, Beale, in 1870, invented the word "bioplasm," to designate the ideal living matter, as involving no theory of living matter, but simply distinguishing it as living. In 1874, Dr. Beale adds, "This I think possible, that after some years have passed, protoplasm may be restricted to living matter only. The term will then be synonymous with bioplasm or living matter, in which case the latter words may be given up." Well, some years have passed—nearly eighteen—and the word bioplasm has been adopted by only a few English biologists, while the word protoplasm has been more and more restricted to the ideal living matter by biologists all over the world, so the time has probably come when the word bioplasm may be withdrawn.

Hanstein suggests the word "protoplastin," to denote the ideal living matter. But if we examine in detail his reasons for the separation of protoplasm from the other contents of vegetable cells, we perceive that his use of the word protoplasm corresponds in all respects with his

* The space for such a word was left blank by me when this paper was read. Afterwards Professor Herdman suggested the word "Necroplasm." I think the suggestion admirable, and have at once adopted it in the glossary at the end of this paper.

definition of protoplastin, and therefore the same purpose would be served by restricting the former word to the ideal living matter.*

With respect to the derivatives from protoplasm, however, the word "bioplast," for the anatomical unit of living matter, seems more convenient than the corresponding word protoplasm-mass, for it was thought by Sharpey that the properly corresponding word "protoplast" was not available in physiology, being already taken up in literature for such a widely different signification. More recently, however, Hanstein,† Schaarschmidt and others, have taken to the use of it in spite of that objection. Häckel's word, "plastid," may also be conveniently used for the anatomical living unit.

The word protoplasmic should be used as synonymous with the words vital and organised. I formerly thought that Schwann's word, "metabolic" should be used to designate the changes of composition taking place in the living matter, in contradistinction to the word chemical as applied to such changes in the laboratory; but I think now that the word protoplasmic should be the word

* The author proposes to admit of a hypothetical material compound or group of compounds, and as such to give the hypothetical name of 'protoplastin' to that single albuminous substance, or that group of several allied albuminates, which according to our present knowledge or rather assumptions—make up the truly active mass of the protoplasm body, and which at present seems alone fitted to be the bearer and starting point, and the only palpable material source of the vital functions and nisus (Triebe)."—Hanstein. *Züge aus der Biologie des Protoplasmas*, p. 10.

† The author thinks proper to designate as 'protoplast' any protoplasm-mass which it is desired to understand and present as a whole, an organised individual or, so to speak, as an active personality; and where such temporarily or permanently, *e.g.* as a swarm-cell, asserts and maintains an independent existence it should be named 'monoplast.' In the same sense the coalescence of several mono- or proto-plasts into a whole may be called 'symplasts.'"—Hanstein (Op. cit., p. 9).

contrasted with chemical, because in all living acts, whether plastic or metabolic, change of composition is essential; Schwann's word metabolic may be still used for vital action in which secretion of chemically different matters from the pabulum is the prominent feature.

Finally, it may be asked, What do we gain by substituting the adjective protoplasmic for vital, and defining as it were in a circle, vitality as the property of protoplasm, while the latter is described simply as matter in the living state? To this may be replied, Much; for thereby we avoid several sources of ambiguity and error, and at the same time place biology in more correct relation with chemistry in its present state. By the above definitions, we emphasise the fact of the residence of vitality in protoplasm alone throughout all nature; and we remove to its proper place the boundary line between chemical and living action. For it is now formally admitted the distinction between the inorganic and organic chemistry of our text books has no existence. It was in fact drawn on the erroneous assumption that synthesis was an essentially vital process and quite outside the sphere of the chemist—an assumption supported by the lack of skill of our chemists sixty years ago. Now, however, so many synthetic products of vital action have been made in the laboratory, and Schunck having stated at the British Association, in 1887, that we may "confidently anticipate that all the most important organic bodies, acids, alkaloids and neutral substances, will in the course of time be obtained in a similar manner," it becomes necessary to recognise in the use of terms that there is no distinction whatever between the chemistry of mineral bodies and that of the dead products of vital action, to which the name of organic chemistry has hitherto been given. To avoid misconception, it will, I think, be better

to abolish the use of the word "organic" in connection with chemistry, and speak of inorganic or mineral chemistry on the one hand and protoplasmic chemistry on the other. The latter would be synonymous with physiology, while the former would comprise both the inorganic and the organic chemistry of our text books. The difficulty is to avoid the word chemical as applied to the vital or protoplasmic state of matter; for if chemistry in the wide sense deals with the affinities and interactions of specifically different kinds of matter, the atomic and molecular interactions of protoplasm which constitute life must belong to chemistry in that wide sense.

To appreciate the profound distinction between the laboratory and the protoplasmic departments of chemistry in its wide sense, let us contrast the very different modes in which a product common to both is formed. On the one hand we see a microscopic portion of protoplasm of a vegetable cell, without any apparatus to separate the different steps of the process, at common temperatures and in the presence of oxygen, forms directly from pabulum, containing none of the immediate precursors of the product, a secretion or substance—such as alizarin—which on the other hand can only be prepared in the laboratory through a long series of processes, some of them in closed vessels, or at high temperature incompatible with life! Further, it was supposed by Liebig, that the process of assimilation in plants begins with the formation of some simply constituted body such as oxalic or formic acid, out of which more complex bodies are formed. But, as is urged by Schunck, "there is not the slightest evidence at present in favour of this view. The first product of assimilation that is distinctly recognised is starch, a highly complex body, which appears at once with all its characteristic properties, like Minerva

springing fully armed from the head of Jove. If we are to adhere to the facts so far observed, we must conclude that the plant does not proceed as we should do in the laboratory, beginning with the more simply constructed compounds and advancing to the more complicated, but that the reverse process is the one actually adopted, the supposed intermediate products being more probably the results of retrogressive metamorphosis."

It is hardly necessary to point out how this agrees with the views expressed above, that the cardinal characteristic of living matter in a chemical point of view is the power of growth or self-renewal from heterogeneous matter, and that in fact growth of protoplasm is the primary element in all tissue formation and secretion. It is also very interesting to notice how—although given out from a standpoint purely chemical—Schunck's mode of expression harmonises with the views of Beale, that all nutrition, secretion and function, depend upon the growth and death of protoplasm. That, in fact, no secretion, even the least complex, is produced by action at a distance, or any catalytic action on the pabulum, but that always a corresponding amount of the highly complex protoplasm is formed, and this by death and retrogressive metamorphosis splits up into the required secretion, while the by-products are taken back into the permanent protoplasm, or absorbed into the circulation. This ought to reconcile Dr. Beale to the abandonment of his word bioplasm in favour of protoplasm, which latter word, it may be recollected, etymologically signifies "that which is first formed."

I conclude with a short glossary, embodying the most important points in the foregoing pages.

Protoplasm. . . = The ideal living matter.

Necroplasm . . = The mass of proteids, fats and salts, into which the above is resolved on rapid death.

Protoplast . . .
Protoplasm-mass.
Bioplast. . . .
Plastid . . . . = The anatomical unit of living matter.

Protoplasmic . . = Appertaining to protoplasm: synonymous with organised, and with vital actions both plastic and metabolic; and as contradistinguished from ordinary chemical and physical actions.

Organisation . . = The process by which a being composed of protoplasm with or without visible structure is formed.

Organism . . . = The composition and structure of a being thus formed.

Vitality . . . . = The property which characterises protoplasm of being acted on by certain powers otherwise than mechanically or chemically in the restricted sense of these words.

Life . . . . . = The interaction of protoplasm with the environment.

The FOUNDATION and FIRST SEASON'S WORK of the LIVERPOOL MARINE BIOLOGICAL STATION on PUFFIN ISLAND.

By W. A. Herdman, D.Sc., F.L.S., F.R.S.E.,

Derby Professor of Natural History in University College, Liverpool; Chairman of the Liverpool Marine Biology Committee, and Director of the Puffin Island Station.

[Read, in part, before the Liverpool Biological Society, 12th November, 1887.]

A full and detailed account of the constitution and objects of the Liverpool Marine Biology Committee having been published last year, as an Introduction to the first volume of Reports upon our local Fauna and Flora,* it is unnecessary now to do more than state that this committee was appointed in the spring of 1885, for the purpose of investigating thoroughly the animals and plants inhabiting Liverpool Bay.

During the summer of 1885 various expeditions were organised by the committee for the purpose of collecting specimens and making observations. Mr. George Holt, Sir James Poole, and the Liverpool Salvage Association gave most welcome aid by placing steamboats at the service of the committee for one or more days. By this means dredging and trawling expeditions to the neighbourhood of Hilbre Island, to Point of Ayr, to Llandudno, and to the neighbouring coasts of North Wales and Anglesey were successfully carried out; while, when steamers were not available, shore expeditions were made to examine Hilbre Island and other points in the estuaries of the Mersey and Dee at low tides.

* First Report on the Fauna of Liverpool Bay and the Neighbouring Seas. Longmans, 1886.

Hilbre Island is certainly one of the most interesting spots in the immediate neigbourhood of Liverpool, from a biological point of view, and has long been well known among local naturalists on account of its comparatively rich marine fauna.* The rocks at the northern end of the island are covered at and about low water mark by a large and varied assemblage of invertebrate animals, and form a particularly favourable locality for certain Hydroid Zoophytes, Actiniæ, Polyzoa, and Nudibranchs. Among the rare animals which have been found on the shores of Hilbre Island may be mentioned *Garveia nutans*, a zoophyte first found in this neighbourhood on the 9th May, 1885, on the first L. M. B. C. expedition; *Cylista undata*, var. *candida*, a new variety of sea-anemone, found by Dr. Ellis on the 11th July, 1885, and described by him in our First Report,† and the rare Nudibranchs *Doris proxima*, *Doris subquadrata*, *Eolis concinna*, *Embletonia pallida*, and *Antiopa hyalina*.‡

The interesting reef-building Annelid, *Sabellaria alveolata*, is found in abundance round some parts of the shore at Hilbre Island, usually near where the sand and rock join. It sticks the sand grains together to form the tubes in which it lives, and so produces a porous, crisp, but brittle rock, which crumbles to a certain extent when walked upon, but which is constantly being renewed and has its injuries repaired by the living worms within, and must therefore have a very considerable effect in protecting the rocks from the erosive action to which all sea coasts are exposed.

The masses, hummocks, plateaux, ledges and small

* See Byerley's "Fauna," Proc. Lit. and Phil. Soc., Liverpool. Appendix to vol. viii., 1853-54.

† See "Fauna of Liverpool Bay." Report on the Actiniaria, p. 126.

‡ See Dr. Collingwood's lists in Ann. and Mag. Nat. Hist., 1859—61.

reefs of this gregarious rock-building Annelid have a curious external resemblance—superficial only, as in structure and mode of formation they are of course utterly different—to the forms produced by coral masses in lagoons and amongst coral reefs and islands. It might be possible by a continuous study, on the spot, of this *Sabellaria* at Hilbre to determine what part the various factors—food, currents, muddy water, presence of sand and rock, exposure to waves, and the arrangement of the animals in the mass—take in producing the various shapes and in promoting or retarding growth.

Another interesting piece of work which could be carried out at Hilbre, or at Puffin Island, would be to determine the various heights above low water mark at which the different kinds of marine animals and plants are able to exist. Many of the Zoophytes and other animals living about half-tide are found to be in a very dry and shrivelled up condition before the tide reaches them, but they revive and expand instantly on being placed in water. I have found the Polyzoon *Flustrella hispida*, at Hilbre Island, in a living and healthy condition only about a yard below high water mark. In such a position the animal must be exposed to the air during about five-sixths of its existence, and since its tentacles can only be expanded when covered with water the entire food supply must be taken in during the remaining one-sixth, at and about the time of high tide. The short opportunity of feeding will therefore only occur twice in each twenty-four hours, and during the long intervals the animal must remain in a contracted and possibly a somewhat dormant condition. It would be important to determine the precise nature of the food of *Flustrella hispida* at Hilbre, and whether it varies with different tides, winds and seasons; and an interesting series of experiments might be made by some

one living on the spot as to the greatest amount of periodic exposure to air which the animal can stand, and also as to what its habits would be if kept continually immersed in water.

So many lists of animals from Hilbre Island, and notes on habits and times of occurrence and other matters have now been collected, that the committee will soon be justified in drawing up from these materials a comprehensive account of the fauna of this isolated mass of rock surrounded on all sides by sand banks. This list when made out will be of considerable scientific interest, for comparison with the notes on the fauna of the island thirty to forty years ago, as recorded by Price and Byerley, and with lists which may be drawn up by other naturalists in the future. There is no doubt that some animals are now found at Hilbre which were not there formerly, and I fear some of the rarer Nudibranchs, which the late Mr. Price discovered, and sent to Alder and Hancock for incorporation in their well-known monograph, have now disappeared from the neighbourhood.

The animals which were collected during 1885 were preserved and stored in the Zoological Laboratory of University College, Liverpool, until the end of the summer. They were then roughly arranged into groups, such as sponges, zoophytes, sea-anemones, worms, molluscs, &c., and sent to those members of the committee and other naturalists who had undertaken to work up and report upon the specimens. This laboratory work went on during the winter 1885-86, and in the spring of 1886 the committee published their first volume of Reports,* containing twenty-nine articles, written by twenty-one authors, and illustrated by ten plates and two maps of the district. These reports record the occurrence of 913

* Fauna of Liverpool Bay, Report I. Longmans, 1886.

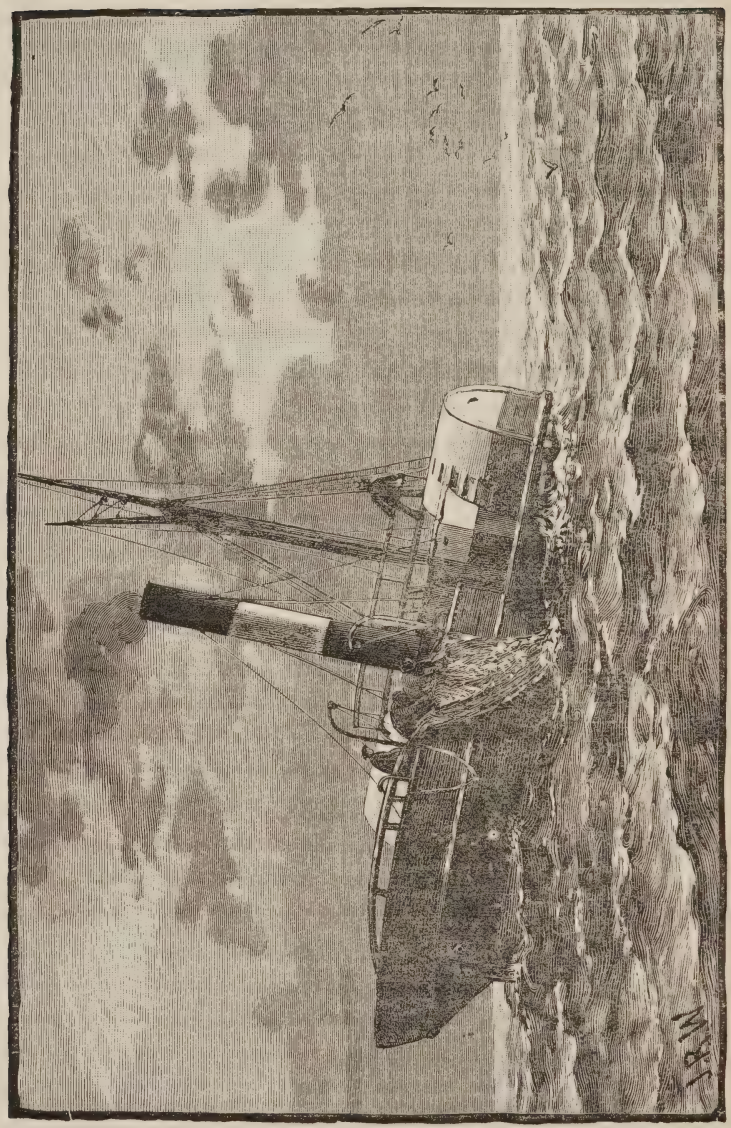

Fig. 1. Dredging in Liverpool Bay—Hauling up the beam-trawl.*

species,† of which at least 235 had not been found before in this neighbourhood. Sixteen of these species have not been previously discovered in British seas, and at least seven species and three varieties are new to science.

Field work was re-commenced in the spring of 1886. Dredging and other collecting expeditions were organized and new parts of the district explored. The steamer "Hyæna" was a second time lent by the Salvage Association for three or four days, and a series of dredgings along the north and west coasts of Anglesey was successfully carried out. The committee was aided financially by a small grant of £25 from the Government Grant Committee of the Royal Society.‡ This along with other funds received was employed in hiring steamers and other boats for expeditions, and in paying fishermen and others for assistance in collecting specimens.

During this second year's work it became obvious to the committee that in order to advance further in their work, so as to be able to make more minute explorations, and to carry on detailed investigations into the habits and life-histories of the animals, it would be necessary to establish a small sea-side laboratory or marine biological station at some suitable spot in the district. Such an institution would require to have a work-room where, say, four to six investigators could have light and room to carry on their researches, and some tanks or aquaria in which animals could be kept under observation in a living condition. If

* For the use of this woodcut, and of figures 2 and 6, I am indebted to the courtesy of Messrs. Cassell and Co. The original drawings were made in illustration of an article "On the Cruise of the Spindrift," by Mr. R. McMillan of Liverpool, which appeared in Cassell's Family Magazine for May, 1886.

† Since increased to over a thousand species.

‡ A second grant of the same amount has been received this year (1887), and employed in a similar manner.

only used in summer it might be made of wood, like the Dutch transportable station established in 1876 by Dr. Hoek, Professor Hubrecht and Dr. Hoffmann, and which was erected at some spot on the coast in summer, and taken to pieces and conveyed to Leyden in the winter; or like the marine station set up by Professor Cossar Ewart at Stonehaven, in 1879, and now at Tarbert on Loch Fyne. On the other hand, if observations are to be carried on all the year round, and if investigators are to live even for a few days at a time in the station, the building would have to be of a more solid and permanent nature.

At first Hilbre Island was thought by the L. M. B. C. to be the most suitable locality in the neighbourhood, and at such a spot a summer wooden station would probably have been sufficient. But further investigations showed that on account of the proximity to Liverpool, and of the constant muddiness of the water at the mouth of the Dee, Hilbre would not be a very favourable locality; while some spot in the centre of a still richer fauna—such as those of North Wales, Anglesey, or the Isle of Man—and in a part of the district which could not be investigated in a single day expedition would be more useful, and would do more to forward the objects which the committee have in view.

During the "Hyæna" expedition of June, 1886, while dredging in the deep water off the northern end of Puffin Island, some of the committee were impressed by the admirable position of the old Dock Board signalling station, on the seaward end of the island (see fig. 3), as a centre for investigating the fauna of the Menai Straits and of the coasts of Anglesey and North Wales. They decided to examine the island and the condition of the house, with the view of trying if possible to convert it into the much needed biological station.

On finding that the fauna on the shores and around the

Fig. 2. Dredging in Liverpool Bay—Emptying the dredge on deck.

island was rich, and that the house, though destitute of doors and windows, was substantial, and could be easily put in good condition, the committee through one of their members, Mr. F. Archer, applied to the solicitor of the Dock Board for permission to convert the Puffin Island observatory into a biological station; and after some correspondence learned that the house had not been used by the Dock Board for over twenty years, and had now lapsed into the hands of the owner of the island, Sir Richard Williams Bulkeley of Baron Hill, Beaumaris. Mr. Archer now applied to Sir R. Bulkeley's agent, Mr. Laurie, through Mr. R. R. Rathbone, and found that the use of the building had been promised some years before to the towns of Bangor, Beaumaris, Conway and Carnarvon, for the purpose of a cholera hospital, if required. This led to further correspondence and a delay of some months; but,

finally, in the spring of 1887, Mr. Archer was able to report to the committee that Sir Richard Bulkeley had kindly consented to let the L. M. B. C. have the use of the house on Puffin Island, as a biological station, at a nominal rent. A few members of the committee went down to the island in March, 1887, in order to examine carefully the condition of the house, and decide what should be done in the way of repairs.

Puffin Island, or St. Seiriol's Isle, or Priestholm, as it is variously called, was then an uninhabited island, with two more or less ruinous buildings:—an old square tower with a pyramidal stone roof, near the centre of the island, and supposed to be the remains of an ecclesiastical building dating back to the twelfth century; and the former Dock Board observatory, a substantial brick and stone building, erected in 1841, and standing close to the cliff on the seaward or northern end of the island (see fig. 3).

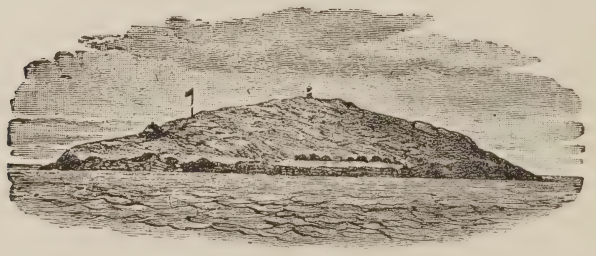

Fig. 3. Puffin Island from the North.*

The island is about five-eighths of a mile in length and 300 yards in greatest breadth. It is separated from the

* For the use of this woodcut, and of figures 4 and 5, I am indebted to the courtesy of Messrs. Macmillan and Co. The original drawings were made as illustrations for my article on Puffin Island, which appeared in "Nature" for July 21st, 1887.

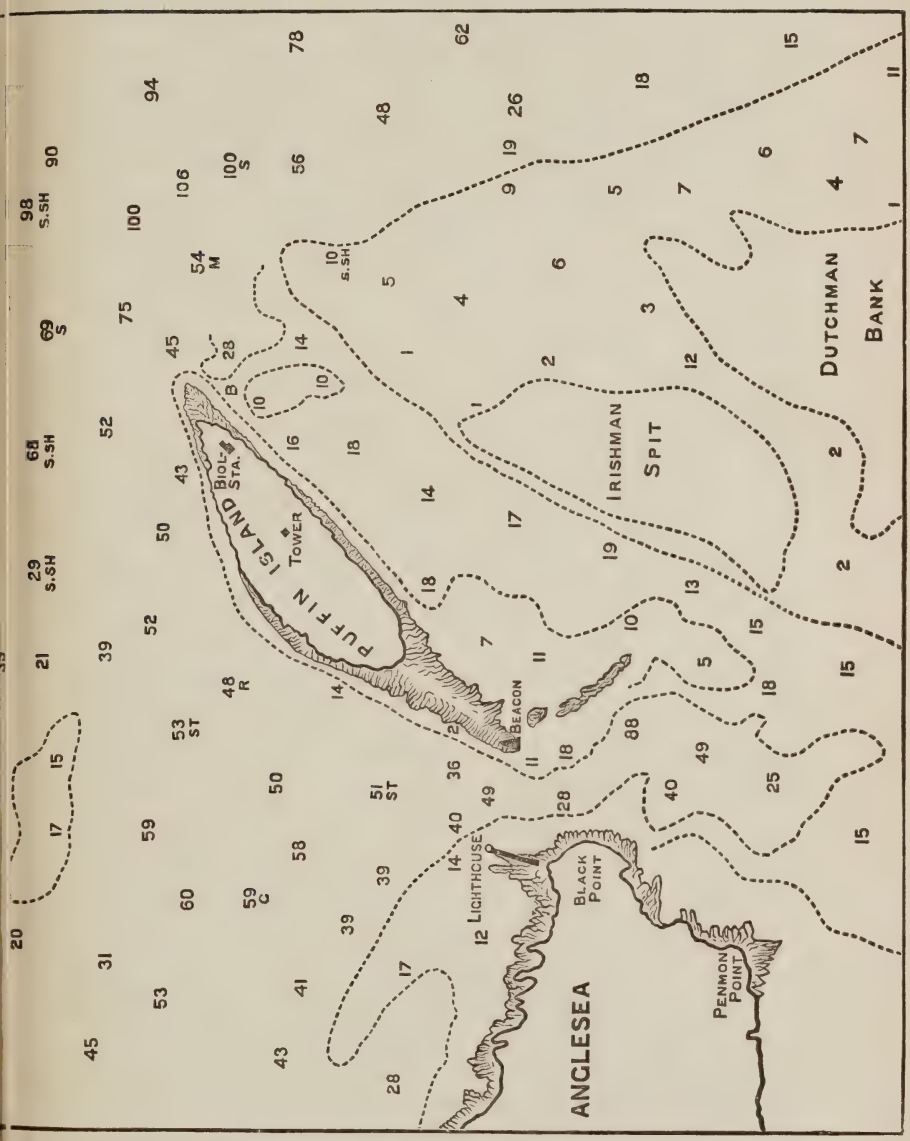

Fig. 4. Chart of the Neighbourhood of Puffin Island. Scale $\frac{1}{24000}$. Depths in feet.

nearest point of Anglesey* (Penmon) by a strait nearly a mile wide, through which the tide runs with considerable force. There are limestone† cliffs round the greater part of the shore, and between tide marks the rocks are considerably broken up and worn, so as to form numerous shore pools, caves and crevices, in which animals abound. The littoral area is rather narrow along the sides of the island, but at the two ends it is of considerable extent. At the south end especially (see Chart, p. 47) it runs out to form a long narrow curved spit, uncovered at low tide, and formed by fragments of rock, boulders and gravel. The larger stones are piled upon one another in such a way as to leave little crevices, nooks, and sheltered pools in which the most fragile organisms can live and flourish protected from the force of the waves and the scour of the sand. This is a rich collecting ground, and many of the rarer animals which have been found during this last summer on Puffin Island were obtained under the stones on this part of the shore.

The former Dock Board observing station was used from 1841 to 1863 for the purpose of watching outgoing and incoming vessels, and of signalling the news by semaphore to the next station on the Great Ormes Head. It consists of a one-storied square house (see fig. 5) of four rooms, with the chimneys in the centre, large lofts above, and a long observatory running out seawards from the northern end. There is a narrow flagged yard in front of the door,

* The nearest neighbours to the Biological Station are the inhabitants of the Lighthouse on this corner of Anglesey. The committee desire to express here their thanks to Mr. J. Steer, the head keeper, for the friendly interest he has taken in their work, and for his kindness in receiving letters and parcels for the Island and for helping in various other ways.

† For an account of the Geology of the Island, see a paper by Mr. Gregory, F.G.S., of the British Museum, further on in the present volume.

and a couple of small outhouses. The walls are unusually thick, and the roofs and floors are in excellent condition.

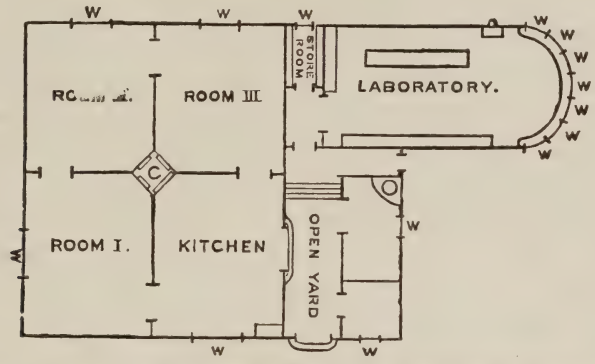

Fig. 5. Plan of the Biological Station. w, w, windows ; c, chimneys.

The small party of naturalists who visited the island in March, 1887, for the purpose of inspecting the house, and deciding upon the repairs and changes necessary in order to convert it into a biological station, were most favourably impressed with the surroundings in every respect. Fortunately, perhaps, for the success of the scheme, the weather was perfect. The sea was calm, and during the row of seven miles from Bangor several casts of the tow-net which were taken showed the presence of a large amount of surface life; while a few hauls of the dredge* made near the island proved that the fauna at the bottom was also abundant, and was interesting in its character. The view of the surrounding land and sea was peculiarly charming. The bright sparkling spring day, the cloudless sky, the snow-clad Welsh mountains glistening in the sun, and the calm blue sea encircling the solitary little island, with its old grey tower rising from the summit, formed altogether a picture never to be forgotten, and perhaps contributed not a little, along with our zoological captures, to the energy

* Fig. 6, on p. 60, shows the dredge.

and unanimity of our determination to report favourably of Puffin Island, and push on the establishment of the biological station without further delay. After a rapid inspection of the island, and a careful examination of the house, all the necessary plans and measurements were made, and we returned in our boat to Bangor.

A joiner was kept hard at work during the next three weeks, in the workshop of the zoological department of University College, making the necessary doors, windows, shutters, shelves, tables, and other fittings for the station; while the committee purchased a few camp beds, hammocks, sailors' mattresses, chairs, kettles and pots, dishes, and other household necessaries for the equipment of the station. When all was ready, the Liverpool Salvage Association again placed their useful steamer, the "Hyæna," at the service of the committee, and a party of about twenty naturalists, with two workmen and all the fittings and furnishings, were conveyed on 27th May, 1887, to the Menai Straits, where they anchored for the night, near Beaumaris.

On the morning of 28th May, the "Hyæna" made an early start, and reached the neighbourhood of Puffin Island about six a.m. To the great disappointment of the whole party, a heavy sea was breaking on the rocks, and after a cruise round the island, in the vain attempt to find a piece of lee shore, Captain M'Lellan decided that it would not be safe to land in the boats. The naturalists being very unwilling to lose the day, the "Hyæna" was kept in the neighbourhood of the island for some time, and fortunately as the tide ebbed sufficient amounts of the "Dutchman" and "Irishman" sandbanks were exposed to form a breakwater protecting the gravel beach at the southern end of the island from the force of the waves. On this spot, at nearly low tide, on the very opposite end of the island

from the house, the tables, chairs, planks, shelves, doors, shutters, windows, beds, packing cases, barrels, tins of paint, sixteen large sacks of coals, and innumerable smaller objects and packages were landed in boat loads, and had to be carried against a strong wind up one end of the island, along the top, and down the other end.

This work kept the whole party hard at work till dark; while the joiners were engaged in putting in doors and windows, so as to have at least one room of the house weather tight before night. A large fire was then lit; camp-beds, hammocks, and shake-downs on reversed tables, doors, shutters and packing cases were prepared, and the party encamped for the night. During the two following days the work went on vigorously, and when, on the 30th May, the committee and their friends returned to Liverpool, the house was in a habitable condition, and the shelves and tables were being fixed in their places. The two joiners were left on the island for a couple of weeks, to complete the fittings, and repair the observatory, which was to be in future the biological laboratory (see fig. 5, p. 49). This room is lit by a continuous series of seven windows, forming a semi-circle round the northern, seaward end; in these there were over a hundred broken panes to be replaced.

The committee engaged as keeper of the station one of the sailors of the "Hyæna," and he was sent down to the island on 3rd June, in charge of a small boat, which had been bought for use at the island. He relieved the joiners, who had then finished their work, but after staying at the station for two weeks, he resigned his post. The committee then chose, from a large number of candidates, the present energetic young keeper, Mr. Alexander Rutherford, who commenced work at the station on 18th June. During the rest of the summer, up to the end of September, a lad

was also engaged to assist the keeper in the work of looking after the station and boat, and of attending to the biologists who visited the island.

The biological station was now fairly established, and during the remainder of the summer work of various kinds was going on steadily. Members of the committee and other scientific men visited the station for periods varying from a day or two to a week or two at a time. During these visits the shores of the island were explored at low tides, tow-nettings and dredgings were taken in the neighbourhood when practicable, and the animals collected were examined and classified in the laboratory. At other times the keeper, when his other duties and the weather permitted, collected specimens by dredging and tow-netting, and on the shore. These he preserved and labelled with locality and date, and either stored in the laboratory or sent to University College, Liverpool, as required.

Shore collecting on Puffin Island on a summer morning, with a low ebb tide, is most delightful work. The naturalist explores the deep crevices and pools in the limestone reefs, lifts up or turns over the smaller of the detached fragments of rock and creeps under the larger ones, peering curiously into all the corners and crannies, and probably oblivious of the pool in which he has placed his knees and of the stream of drops which is trickling down the back of his neck. He sees covering the lower surface of the stones and festooning the rock delicate sprays of beautifully shaped Zoophytes, elaborately sculptured Polyzoa, and masses of incrusting Sponges with gorgeous colouring. He sees strange looking masses of Ascidians, which if incautiously touched suddenly emit two tiny jets of water, thus vindicating their claim to the title of "sea-squirts." These and various other marine animals—especially the sea-anemones and the Nudi-

branchs—almost defy description; they must be seen to be appreciated.

It is proposed to divide the littoral zone of the island into several regions or sub-zones, and investigate the Fauna and Flora of each separately, so as to determine their characteristic animals and sea-weeds, and the relative capacities the different species possess for withstanding exposure to air and sunshine. At the northern end of the island, close to the Biological Station, some of the larger rock-pools might be easily converted into natural aquaria, enclosed with wire netting, so as to exclude stones and sea-weed and prevent the animals placed in the pools from escaping at high tide. The water in these aquaria would be renewed at every tide, and the animals would be under natural conditions and yet could be easily watched, and caught when necessary for closer examination. Many of the Zoophytes and Polyzoa seem to adhere in greater numbers and grow to a larger size on fragments of water-logged wood from wrecks than on the stones. Such pieces of wood, as well as other suitable substances, and also various glass vessels could be readily suspended in these rock-pool aquaria, and so be available when required for examination. These and various other methods for facilitating the study of the shore Fauna we intend to carry out during the coming summer.

The following biologists have worked at the station since its establishment in the beginning of June, 1887:—

Mr. J. A. Clubb, Assistant in the Zool. Lab., Liverpool.
Dr. Ellis, Liverpool.
Mr. Harvey Gibson, Lecturer on Botany, Liverpool.
Mr. Gregory, F.G.S., British Museum, London.
Dr. Hanitsch, Demonstrator of Zoology, Liverpool.
Professor Herdman, Liverpool.
Mr. Leicester, Liverpool.

Mr. Lomas, Liverpool.
Dr. Paul, Liverpool.
Mr. I. C. Thompson, F.L.S., Liverpool.
Mr. A. O. Walker, F.L.S., Chester.

Various other scientific men have visited the station without doing any special work, and on the 3rd September a party of biologists from the Meeting of the British Association at Manchester—including Professor Fritsch, Prague; Prof. Giard, Paris; Prof. Julin, Liège; Prof. Howes, London; Prof. Parker, Cardiff, and others—visited the island for a short time, and inspected the biological station, while on a dredging expedition in the steamer "Gamecock."

Besides the collecting and identifying of specimens, work which we have all of us been engaged in more or less, various pieces of research have been commenced and are partially or wholly completed. Mr. Lomas has been investigating the Polyzoa, and has found some rare forms new to the locality. He has also been working at some points in the structure of *Alcyonidium gelatinosum*, a large fleshy Polyzoon which is very common attached to the rocks near low water. He has found calcareous spicules in the outer jelly-like part of the colony, and has also made observations upon some other points in the minute structure of this interesting animal (see his papers read before the Biological and Geological Societies of Liverpool).

Mr. Leicester has been collecting and examining the land Mollusca of Puffin Island (see paper read before the Biological Society), and is also working at the marine Rotifera.

Mr. Gregory, of the British Museum, besides preparing a report upon the geology of the island, has been investigating the Annelids (see papers read before the Biological Society), and will take charge of this group in future.

Dr. Hanitsch has commenced some researches upon the minute structure of some of the Mollusca.

Mr. Thompson has taken charge of the surface life of the sea, and has been specially investigating the Copepoda, a group of small Crustacea.

These animals and many others, including the larval stages and other young forms of vast numbers of animals which are fixed or live at the bottom of the sea when fully developed—such as barnacles, crabs, molluscs, annelids, polyzoa, star-fishes, sea-urchins, and zoophytes—are found swimming at or near the surface of the sea, and form a most important part of the marine Fauna. They are captured by means of the tow-net, a long conical bag of canvas, silk-gauze or strong muslin, attached to an iron hoop about a foot in diameter, and tapering to a closed end, into which a small glass bottle or tube may be inserted if required. The tow-net is let down over the stern of the steamer when going slow, and is dragged along just below the surface of the water for half an hour or so. It is then pulled on board and turned inside out into a glass vessel of sea-water, when the minute organisms which have been captured become detached from the inner surface of the net and float about in the water, from which they can then be removed by a fine glass dipping tube and placed in a watch-glass of sea-water under the microscope.

Generally the contents of the tow-net are very largely composed of Copepoda, small Medusæ or jelly-fishes, and larval stages in the development of other animals ; but at certain times Mr. Thompson has noticed* the presence of an extraordinary number of small spherical gelatinous

* See "Nature," for 23rd July, 1885, under heading "Foul Water." Mr. Shrubsole has noticed the same condition off Sheerness, and Professor McIntosh describes it also as occurring in St. Andrew's Bay (Ann. and Mag. Nat. Hist., Aug., 1887).

bodies, which are apparently lowly developed plants, in the surface waters round Puffin Island and at the mouth of the Dee. Associated with these are found large quantities of *Noctiluca*, the organism which causes a great deal of the phosphorescence of the sea round our coasts, but as a rule when the gelatinous Algæ are present very few of the ordinary surface animals such as Copepoda are found in the tow-net.

Besides discovering a large number of species of Copepoda, including various rare forms (see his papers in Proc. Biol. Soc.), Mr. Thompson has found four species new to British seas, and two others which have not been found for fifty and thirty years respectively, while the following three species are new to science: *

1° *Cyclops puffini*, n. sp. (I. C. T.)

This form was first found in a tow-netting by Mr. Thompson, taken from the steamer "Gamecock," during the visit of the British Association to Puffin Island, on 3rd September, 1887. It has since been found in tow-net gatherings taken by the keeper round the shores of the island.

2° *Lichomolgus sabellæ*, n. sp. (I. C. T.)

This is an exceedingly interesting parasitic species, which was found by Mr. H. C. Chadwick adhering to the tentacles of an Annelid, *Sabella penicillus*, obtained on the shore near Beaumaris. The posterior antennæ of the Copepod are remarkably modified, and are provided with powerful hooks by means of which it attaches itself so firmly to the tentacles of the Annelid, that even after being killed and preserved in alcohol it is only with difficulty that it can be removed from its host.

* For detailed descriptions and figures, see Mr. Thompson's paper further on in this volume.

3° *Scaphosoma herdmani*, n. sp. (I. C. T.)

A very remarkable form, with a long narrow body. It was first found in a tow-net gathering taken off Puffin Island, on an autumn night this year, and was at once recognised as being an interesting new species belonging to the new genus *Scaphosoma*, founded by Mr. Thompson, in a paper on the Copepoda of the Canary Islands, read before the Linnean Society of London, on 17th November, 1887, for the reception of the new species *Scaphosoma rigidum*, which he had found on the surface off Teneriffe. Curiously enough, another specimen of *Scaphosoma herdmani* has since been found in a tow-net gathering taken in the Mediterranean, off Malta, by Dr. D. Bruce, and sent to Mr. Thompson for examination. So that single specimens belonging to the new genus *Scaphosoma* have been found lately in such far distant localities as Puffin Island, Teneriffe, and Malta.

Some of the more interesting Copepoda found round Puffin Island have been taken in the night. The distribution of these surface organisms, both according to the time of the day and season, and also according to the depth, is still very imperfectly known. There is great need of some simple yet efficient contrivance by which a tow-net could be let down closed to a certain depth, then be opened and used at that depth, and then be closed again and hauled up, so as to ensure that all its contents were really obtained from a certain stratum of water. The "Turbyne" tow-net, devised and used at the Scottish Marine Station, Granton, seems but a rough and imperfect form of the desired instrument, and would probably give only approximately correct results.

In the beginning of October, a meeting of the L. M. B. Committee was held at University College, to receive a

report upon the work that had been done during the summer, and to decide upon future plans. Altogether nearly £140 had been received during the summer, in the form of donations,* and the greater part of this had been expended in repairing and fitting up the station, and in paying the wages of the keeper and his assistant. A small steam-launch, the "Puffin," twenty-six feet in length, had also been obtained, but as stormy weather had already set in, it was thought best not to take the little vessel down to the island till spring. She is now in dock, and it is hoped that she will be of great service next summer in keeping up communication from the station with Beaumaris and Bangor, and for dredging round the island.

One of the most important matters to be settled by the committee was whether or not the station should be closed up during the winter. For several reasons it was thought very desirable to keep it open all the year round—so as to be able to obtain specimens in various stages of development, and so that observations could be made upon the winter as well as the summer fauna of the shores and of the surface waters of the sea—and as Mr. Rutherford, who had recently married, offered to carry on his duties as keeper during the winter without an assistant, the committee decided it should not be closed, so long as the funds at their disposal sufficed to pay the working expenses.

Since the beginning of October there have been few visitors at Puffin Island. Although in summer the island is easily reached from Liverpool by means of the fast steamers from the landing stage to Beaumaris, in winter it is rather difficult of access and the journey is long and troublesome. One has to take train by Chester and North Wales to Bangor, and then either proceed by coach round by Menai Bridge to Beaumaris, or walk to Garth Ferry,

* See list, p. 63.

cross the Straits and then walk or drive two miles to Beaumaris. If the weather is favourable the boat from Puffin Island can come up to Beaumaris, but when that cannot be managed a further walk or drive of four miles to Penmon Point is necessary.

During the gale of 1st November, the flat "Myra," of Runcorn, was wrecked upon the rocks near the south end of the island, and our keeper, with the assistance of two rabbit-catchers, succeeded in lowering a rope to the vessel and hauling two men up the cliff—a boy was unfortunately drowned. The men were kept at the station until the gale was over, and were then taken in the boat to the mainland.

At the beginning of December I visited the island for a few days, with the object of examining the fauna on the rocks in winter, and also in order to see that all was going on well at the station. I found that Mr. and Mrs. Rutherford had been working hard to improve the condition of the house and the laboratory, and were performing their duties with energy and with an intelligent interest in the work. When the weather permitted, tow-net gatherings were taken, sometimes in the daytime and sometimes at night. These were carefully preserved and labelled, with the locality, date, and other conditions, and were forwarded to Mr. Thompson, for examination. The dredge was also used when possible, and the shores were explored at low tides. During the late autumn and winter the phosphorescence in the sea has sometimes been exceedingly brilliant. It appears to be always due in this neighbourhood to *Noctiluca miliaris*, which is frequently present on the surface in great abundance.

This work will be carried on systematically during the remainder of the winter, and the specimens so collected will form a most valuable mass of material for detailed investigation and for comparison with the marine fauna

found in summer. A good deal of what has been collected at Puffin Island during the summer, autumn, and early part of winter, has already been separated into groups and sent to the various specialists to be worked up.

One or two of our Liverpool naturalists may possibly be working at Puffin Island during the Christmas vacation, and several biologists and students have already intimated their intention of making use of the station during Easter. About that time the steam-launch will probably be taken down, and the dredging expeditions of the committee will be resumed.

From this account of the first season's work at our biological station it is evident that the institution has already begun to be of service to science, and may be confidently expected in the future—if the committee are properly supported in their efforts—to be a great boon to students of natural science in this neighbourhood. In addition to the support which the members of the committee can give in money, apparatus, and other supplies, a small fixed income of about £100 a year will be sufficient to meet the bare working expenses on the present modest scale. This might be provided (1) by raising a permanent endowment; (2) by a sustentation fund for, say, five years; or (3) by yearly subscriptions. The committee have not yet decided upon a definite plan of action for next year, but in the meantime subscriptions or donations will be gladly received by the Hon. Treasurer, Mr. Thompson, 19, Waverley Road, Liverpool.

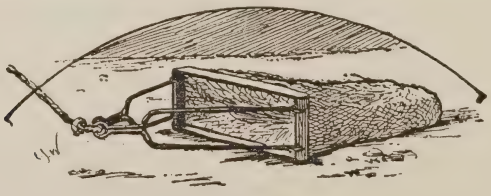

Fig. 6. The dredge.

List of Donations.

Mr. George Holt	£50	0	0
Duke of Westminster	5	0	0
Earl of Derby	5	0	0
Dr. Drysdale	5	0	0
Mr. H. Rees Davies	5	0	0
Mr. I. Roberts, F.G.S.	5	0	0
Mr. A. O. Walker, F.L.S.	5	0	0
Sir James Poole (Mayor)	3	3	0
Prof. Mitchell Banks	3	3	0
Mr. H. W. Gair	3	3	0
Mr. Malcolm Guthrie	3	3	0
Mr. W. G. Scott	3	3	0
Mr. F. Archer	2	2	0
Prof. Herdman	2	2	0
Mr. T. D. Hornby	2	2	0
Mr. C. W. Jones	2	2	0
Mr. E. K. Muspratt	2	2	0
Mr. W. S. McMillan	2	2	0
Mr. W. Rathbone, M.P.	2	2	0
Mr. T. Rathbone, F.L.S.	2	2	0
Mr. A. Norman Tate	2	2	0
Prof. Campbell Brown	2	0	0
Mr. W. B. Halhed	2	0	0
Mr. F. Massey	2	0	0
Dr. Bark	1	1	0
Mr. Nath. Caine	1	1	0
Mr. T. Holder	1	1	0
Mr. A. Leicester	1	1	0
Mr. T. J. Moore	1	1	0
Mr. W. Nicol	1	1	0
Mr. I. C. Thompson, F.L.S.	1	1	0
Dr. Weightman	1	1	0
Dr. Caton	1	0	0

Rev. H. H. Higgins	1	0	0
Mr. R. R. Meade-King	1	0	0
Miss Lushington	1	0	0
Mr. R. R. Rathbone	1	0	0
Mr. D. W. Main	0	10	6
Mr. H. K. Smith	0	10	6
Mr. Seth Wrigley	0	10	6
Dr. Barron	0	10	0
Mr. Cedric Boult	0	10	0
Mr. A. Fergusson	0	10	0

The following pieces of apparatus or furniture have also been given to the station :—

Stove for laboratory	Sir James Poole.
Microscope with three Hartnach objectives, some dissecting instruments, and other laboratory necessaries	Prof. Herdman.
Dissecting microscope	Dr. Weightman.
Tables, chairs and chest of drawers	Mr. A. Leicester.
Paraffin stove	Mr. Harvey Gibson.
Large filter	Salvage Association.
L. M. B. S. flag	Mrs. Ellis.
Pennington's "British Zoophytes."	Mr. J. Lomas.
Four large iron fenders	Mr. J. Vicars.
Sprit sail for boat	Mr. A. Rutherford.
Large screen	Mr. I. C. Thompson.

SECOND REPORT on the COPEPODA of LIVERPOOL BAY.

By Isaac C. Thompson, F.L.S., F.R.M.S.

With Plates I. and II.

[Read 12th November, 1887.]

Since the last Report on the Marine Copepoda of the district, thirty-one additional species have been recorded, making fifty species altogether known to the district. Four of them are new to Britain, three of them being altogether new to science. Two of the other species have not been before recorded in Britain for fifty and thirty years respectively.

Some of the species noticed in the first Report as having been found locally or sparingly have since proved to be very common throughout the district. Of these may be mentioned *Pseudocalanus elongatus*, *Dias longiremis* and *Oithona spinifrons*. *Calanus finmarchicus* then alluded to as not having been found nearer than the Isle of Man, was subsequently taken by tow-net, during the "Weathercock" excursion, far out at sea, at about the centre of the L.M.B.C. area, and has since been taken off Puffin Island.

The establishment of the Biological Station on Puffin Island has greatly aided tow-netting operations, and many of the rarer forms obtained have been found in material forwarded therefrom. Mr. Rutherford, the curator, collects whenever the weather renders tow-netting operations practicable and forwards the material at once by post. On a recent occasion, during the early morning hours of

a dark cold night, the tow-netting from Puffin Island consisted of quantities of *Tomopteris* and *Sagitta*, with only a few Copepoda. It is, however, noticeable that with the exception of *Trebius caudatus* (referred to later) the night collections have hitherto been little different from those of the day. During the early spring of the present year, I noticed on several occasions large quantities of diatomaceous matter floating near the surface of the sea, but it disappeared about May, and there has been no observation of the gelatinous Algæ referred to in last Report about our coasts.

The thirty-one species recorded since the last Report are as follows :—

Family Calanidæ.

Paracalanus parvus, Claus.

This rare form, described by Claus in his work on the marine Copepoda of Trieste, was taken by tow-net near Puffin Island, in September, in the "Gamecock" expedition.

Dias discaudatus, Giesbrecht.

Taken off the Anglesey coast by tow-net on the "Hyæna" expedition.

Temora velox, Lilljeborg.

This brackish water species is probably somewhat common in the district about salt marshes. Mr. W. S. McMillan found it as far inland as Sefton, and we recently together found it plentiful in the long narrow pools immediately behind the Leasowe breakwater.

Eurytemora hirundo, Giesbrecht.

This rare form, hitherto unknown to Britain, was found in two early morning gatherings, tow-netted by Mr. Clubb, in the Crosby Channel, and was referred to at length in a paper read before the Biological Society last session.

Pontella wollastoni, Lubbock.

This species, with the last, was referred to specially in a recent paper (Proc. L'pool Biol. Soc., vol. I., Pl. VI.) as having been found during the "Weathercock" expedition, the only previous record of its occurrence near Britain being by Sir John Lubbock, who took it at Weymouth in 1857. It has since occurred during the past summer in several gatherings taken around Puffin Island.

Parapontella brevicornis, Lubbock.

Found sparingly in the open sea, and more recently around Puffin Island.

Isias clavipes, Boeck.

Taken on several occasions in the open sea some miles from land. Neither Boeck nor Brady notice a pair of remarkable trifid spines which occur one on each side of the first abdominal somite of the female.

Family Cyclopidæ.

Thorellia brunnea, Boeck.

Found very sparingly in the open sea.

Cyclopina littoralis, Brady.
C. gracilis, Claus.

Both of these species of *Cyclopina* have been found in recent tow-net gatherings about Puffin Island.

Cyclops puffini, n. sp. (Pl. I., figs. 1 to 9).

Length 1-20th inch. Cephalothorax five jointed, the first about as long as the remaining four. Anterior antennæ (fig. 2) six jointed and clothed with fine setæ, the third joint longer than any of the others. In the male the second and third joints from the apex are very wide

at their terminations, strong spines proceeding therefrom. Posterior antennæ (fig. 3) terminated by several spines and plumose setæ. Mandible (fig. 4) divided at apex into long slender spinose teeth. Maxilla (fig. 5) furnished with several plumose spines; termination of palp has deeply serrated edge. Footjaws (figs. 6 and 7) slender, with spines at apex. First four pairs of swimming feet (fig. 8) two jointed, the basal joint serrated on outer edge, outer joint strongly spined. Fifth pair swimming feet (fig. 9) composed of one joint only, with one side serrated, the other having short setæ and terminated by one single spine and two serrated leaf-like spines. Abdomen three jointed in both sexes; the first joint is doubly toothed at posterior angles; second joint also toothed and shorter than the others. Caudal segment about twice as long as broad, with a seta about middle on each outer side, and terminated by several setæ, the largest on each side being widely barbed near the apex and plumose below.

First found among the tow-net gatherings from "Gamecock," taken off Puffin Island, and since found sparingly in same locality.

Family Harpacticidæ.

Longipedia coronata, Claus.

Common near coast line throughout the district.

Laophonte similis, Claus.
L. curticaudata, Boeck.

Found in the peaty pools of submarine forest at Leasowe.

L. serrata, Claus.

One specimen only of this rare species was taken recently, by tow-net, off Puffin Island.

Euterpe gracilis, Claus.

Several specimens of this rare form have been taken about Puffin Island during the past summer. Brady, in his "Monograph of British Copepoda" (Ray Society, 1876—1879), states there have been previously only two known habitats for this species, viz. Heligoland, and Kinsale harbour, Ireland. I recently found it about the Canary Islands.

Dactylopus tisboides, Claus.
D. stromii, Baird.
Diosaccus tenuicornis, Claus.

These three species have been sparingly found by Mr. W. S. McMillan and myself in the peaty pools about the submarine forest, Leasowe.

Thalestris clausii, Norman.
T. rufocincta, Norman.
T. hibernica, Brady and Robertson.
T. longimana, Claus.

These four species of *Thalestris* I have found at various times in the rock pools about Hilbre Island.

Westwoodia nobilis, Baird.

Rock pools at Hilbre Island.

Harpacticus fulvus, Fischer.

Rock pools at Puffin Island, also about Hilbre Island.

Peltidium interruptum, Goodsir.

Rock pools at Hilbre Island and by tow-net off Anglesey, and frequently around Puffin Island.

Idya furcata, Baird.

At Penmaenmaur, in open sea and in tidal pools.

Family Corycæidæ, Dana.

Lichomolgus sabellæ, n. sp. (Pl. II., figs. 1 to 9).

Length, female 1-10th inch, male 1-15th inch. Body ovate, first segment nearly half the length of the cephalothorax. Rostrum short and beak-like. Anterior antennæ (fig. 2) alike in both sexes, composed of seven joints, the two basal joints large and strong and about equal in length to the other five; their edges are roundly serrated and curled over, with several setæ. The third joint has three long setæ on inner margin, and the terminal joint has several long setæ at apex. Posterior antenna (fig. 3) also alike in both sexes, four jointed; the second joint has four teeth placed longitudinally; the terminal joint has several hooked claws both at side and at apex, the latter having also several long setæ. The mandible is strongly toothed, the terminal portion having three spines. The maxilla (fig. 4) has a long process terminated by a blunt spine, and bearing on each side a row of sharp teeth similar to those of the mandible; the other extremity has five digital spines. Anterior footjaw (fig. 5) two jointed; the second joint terminated by four short spines. Posterior footjaw two jointed; that of the male (fig. 7) is terminated by a long falciform claw, similar to that of *L. fucicolus*, Brady, that of the female (fig. 6) is elongated and terminated by three claw-like spines. Swimming feet of the first four pairs are two branched (fig. 8), each branch three jointed and bearing several spines and plumose setæ. The fifth feet (fig. 9) in both sexes are composed of one short straight joint terminated by two spines. Abdomen is five jointed in each sex; the first joint nearly equal in length to the remaining four and much broader, especially in the male. The caudal segments are parallel and about three

times as long as broad, and each terminated by four setæ, in addition to a small seta about the middle of outer edge.

Several specimens of this strongly marked species were sent to me by Mr. Herbert Chadwick of Manchester, adherent upon a species of *Sabella* found on the Beaumaris beach, and of which he informs me all the specimens he found were similarly infested. Although preserved in alcohol the crustaceans tenaciously adhered by their hooked antennæ to the tentacles of the *Sabella*, from which it required some force to remove them. The females were the most plentiful, though several of both sexes were on a single worm. The species is easily distinguished by its long narrow ovisacs and remarkable antennæ; it is of a greyish brown colour.

Family Artotrogidæ.

Acontiophorus scutatus, Brady and Robertson.

One specimen only found on Algæ in rock pools at Hilbre.

Family Caligidæ.

Trebius caudatus, Kroyer (Pl. II., fig. 10).

A few specimens of this parasitic species were found in recent night tow-nettings taken off Puffin Island. Baird gives a small figure of it in his "Natural History of the British Entomostaca" (Ray Society, 1849). He states that it was found on a skate in Belfast Lough, by Mr. Wm. Thompson, in 1837, since which time it does not appear to have been recorded. The few specimens I have found being all taken at night would seem to indicate that it is only then a free swimmer.

Family Cymbasomatidæ.

Cymbasoma herdmani, n. sp. (Pl. I., figs 10 to 12).

Length 1-10th inch. Cephalothorax nearly the same width throughout, truncated at each end, five jointed, the first joint being nearly equal in length to the remaining four. Anterior antennæ of male (fig. 11) five jointed, strong and muscular—the fourth joint being nearly equal in length to the preceding three; there is a hinged joint between the fourth and terminal. There are several spines and setæ throughout the antennæ, the apex bearing a terminal claw. First four pairs of swimming feet alike in structure (fig. 12), the basal joint very large. Both branches three jointed, and clothed with strong spinose setæ. Abdomen of male five jointed, gradually getting smaller, the fifth being wedge-shaped laterally. Caudal segments divergent and stumpy, a little longer than broad, each terminated by six spinose setæ.

One specimen only, a male, was found in an autumn night's tow-netting, taken off Puffin Island; and I have since found another in a tow-net gathering sent from Malta by Dr. Bruce. The only hitherto known species of this genus, *C. rigidum*, Thompson,* was taken by tow-net off Teneriffe.

It is with peculiar pleasure that I name this species in honour of my friend Professor Herdman, the founder of Puffin Island Biological Station, to whom I am indebted for help on many occasions.

* Described in a paper read before Linnæan Soc., London, Nov. 17 1887

Description of Plates.

Plate 1.

Fig. 1. *Cyclops puffini*, n. sp., female, × 150 diams.
Fig. 2. Anterior antenna of do. 250 ,,
Fig. 3. Posterior antenna of do. 250 ,,
Fig. 4. Mandible of do. 400 ,,
Fig. 5. Maxilla of do. 400 ,,
Fig. 6. Anterior footjaw of do. 400 ,,
Fig. 7. Posterior footjaw of do. 400 ,,
Fig. 8. One of third pair swimming feet of do. 400 ,,
Fig. 9. One of fifth pair swimming feet of do. 400 ,,
Fig. 10. *Cymbasoma herdmani*, n. sp., male, 150 ,,
Fig. 11. Anterior antenna of do. 250 ,,
Fig. 12. One of swimming feet of do. 250 ,,

Plate II.

Fig. 1. *Lichomolgus sabellæ*, n. sp., female, × 150 diams.
Fig. 2. Anterior antenna of do. 250 ,,
Fig. 3. Posterior antenna of do. 250 ,,
Fig. 4. Maxilla of do. 400 ,,
Fig. 5. Anterior footjaw of do. 400 ,,
Fig. 6. Posterior footjaw of do. 400 ,,
Fig. 7. Posterior footjaw of male, 400 ,,
Fig. 8. One of fourth pair of swimming feet, 400 ,,
Fig. 9. One of fifth pair of do. 400 ,,
Fig. 10. *Trebius caudatus*, Kroyer, 150 ,,

Cylista coccinea, Müll, an ACTINIARIAN new to LIVERPOOL BAY.

By John W. Ellis, L.R.C.P., F.E.S.

[Read 12th November, 1887.]

On Whit-Monday (14th June, 1886), while the "Hyæna" was on her homeward passage, having left Holyhead about four a.m., to escape as far as possible a gathering storm, and when about three miles S.S.E. of Point Lynus, a cast of the dredge was taken in about twelve fathoms of water. When hauled on board, the dredge was perfectly full of fine specimens of *Spatangus purpureus*, a sea-urchin which had scarcely, if at all, been noticed in any of the previous L. M. B. C. expeditions. Among the rubbish at the bottom of the dredge were a few broken razor-shells (*Solen ensis*), and upon a valve of one of these a small anemone was observed, and handed to me for identification. During the passage home the specimen remained in a contracted condition, and not until two days after its arrival in Liverpool did it expand its tentacles sufficiently for a correct diagnosis of the species to be made, but then the salmon-red column with white longitudinal stripes, and the pellucid tentacles, with opaque white rings and black bar, showed it to belong to a species hitherto unrecorded for the L. M. B. C. district, and a prize wherever found in British seas, viz. *Sagartia coccinea*, Müll, of Gosse's "Actinologia Britannica," *Cylista coccinea*, Müll, of the "Fauna of the Gulf of Naples.

This beautiful species is recorded by Gosse, on the authority of Professor Forbes, from "the Irish coast, on rocks and seaweeds," a vague locality, and as found by

Mr. C. W. Peach in two localities as distant as can be found in Britain, viz. the coasts of Caithness and Cornwall. Professor A. C. Haddon, of Dublin, informs me that he has not met with this species in his investigation of the marine fauna of Dublin Bay, and this, together with the fact that it has not been observed, either before or since, during any of our own excursions, leads one to the belief that it is a very local species in its distribution. Gosse describes its mode of life as being "adherent to shells in deep water," and the account of the species in the "Fauna of the Gulf of Naples," describes it as occurring on shells, often in great numbers, *Ostrea* being particularly specified.

Gosse calls attention to the peculiar ocellated appearance presented by the partially expanded tentacle when looked at from the apex, an appearance which led him to give it the trivial name of the "eyed" anemone.

The specimen taken off Point Lynus lived only a few days, and though I suggested that it should be sought for on the last "Hyæna" expedition, our time was so fully occupied in fitting up our station at Puffin Island that no opportunity was afforded for an investigation of what I feel sure will prove most interesting collecting ground, and that too within very easy reach of our biological station on Puffin Island.

REPORT on the POLYZOA of PUFFIN ISLAND.

By Joseph Lomas, Assoc. N.S.S.,
SPECIAL LECTURER ON GEOLOGY IN UNIVERSITY COLLEGE, LIVERPOOL.

[Read 12th November, 1887.]

The shores of Anglesey have long been famous for their zoophytal Fauna. Ellis, in his "Essay towards a Natural History of the Corallines" (1755), speaks of receiving "Zoophytes" from Anglesey in 1751, and it was most probable that their animal nature was discovered by him whilst examining these specimens.

Professor E. Forbes, F.R.S., in the British Association Reports for 1850, gives the following ten species of Polyzoa as occurring on the Anglesey coasts:—

Diastopora obelia.
Crisia sp.
Hippothoa sp.
Cellepora pumicosa.
Lepralia sp.
Flustra foliacea.
Flustra coriacea, Johnst.,
(= *Membranipora hexagona*, Busk.)
Salicornaria farciminoides.
Alcyonidium sp.
Sertularia lendigera.

It is worthy of remark that Forbes, in his reports, always gives the depths at which the specimens were found, and also the character of the bottom. The latter point is often omitted in reports, though it is of great importance in explaining peculiarities of distribution.

The L.M.B.C. have made several visits to the Island

and neighbourhood, and a deep hole on the N.E. of the station has yielded very good material.

The following species have not yet been recorded from any other part of the L. M. B. C. district :—

Mucronella ventricosa.
Stomatopora granulata.
Valkeria uva, form *uva*.
Membranipora monostachys.
Bugula purpurotincta.
Scrupocellaria ciliata.
Mastigophora hyndmanni.
Bugula turbinata (new var.)
Crisea eburnea var. *aculeata.*

The last four are given on the authority of Mr. R. Kirkpatrick, of the Natural History Museum, South Kensington, who identified the specimens collected by Mr. Gregory, during August, 1887.

From all sources I am able to record fifty-two species:—

Aetea anguina, L.
Eucratea chelata, L.
Gemellaria loricata, L.
Scrupocellaria scruposa, L.
,, *reptans*, L.
,, *ciliata.*
Bicellaria ciliata, L.
Bugula turbinata, Alder.
,, *flabellata*, J. V. Thomp.
,, *avicularia.* L.
,, *plumosa*, Pallas.
,, *purpurotincta*, Norman.
Cellaria fistulosa, L.
Flustra foliacea, L.
,, *papyracea*, Ellis and Sol.

Membranipora lacroixii, Aud.
,, *monostachys*, Busk.
,, *pilosa*, L.
,, *flemingii*, Busk.
,, *hexagona*, Busk.
,, *lineata*, L.
,, *membranacea*, L.
Schizoporella auricula, Hassall.
,, *hyalina*, L.
Mastigophore hyndmanni, Johnst.
Hippothoa distans, McGill.
,, *divaricata*, L.
Lepralia foliacea, Ellis and Sol.
Mucronella variolosa, Johnst.
,, *coccinea*, Abild.
,, *ventricosa*, Hassall.
Cellepora pumicosa, L.
,, *costazii*, Aud.
Crisia cornuta, L.
,, var. *geniculata*, M—Edwards.
,, *eburnea*, L.
,, *denticulata*, Lamk.
Stomatopora granulata, M—Edwards.
Idmonea serpens, L.
Diastopora patina, Lamk.
,, *obelia*, Johnst.
Alcyonidium gelatinosum, L.
,, *hirsutum*, Flem.
,, *mytili*, Dal.
,, *parasiticum*, Flem.
Flustrella hispida, Fabr.
Vesicularia spinosa, L.
Amathia lendigera, L.
Bowerbankia imbricata, Adams.

Bowerbankia pustulosa, Ellis and Sol.
Valkeria uva, form *uva*, L.
,, ,, form *cuscata*.
Pedicellina gracilis, Sars.
,, *cernua*, Pallas.

In a former Report ("Fauna of Liverpool Bay," vol. i., p. 162) ninety-eight species of Polyzoa were recorded. Eight species have since been added, and along with a variety now raised to the dignity of a new species (*Ascopodaria nodosa*), bring the total number of Polyzoa now known from the L.M.B.C. district up to one hundred and six.

The GEOLOGY of PUFFIN ISLAND.

By J. W. Gregory, F.G.S.,
GEOLOGICAL DEPARTMENT, BRITISH MUSEUM.

[Read 10th December, 1887.]

Puffin Island is a knoll of Carboniferous limestone, lying a mile from the easternmost point of Anglesey, and forming part of the north shore of the Menai Straits. The island is three quarters of a mile long by a quarter broad, its longer axis lying N.E. and S.W., the backbone consisting of a ridge, at one place 195 feet high, traversing the island close to the south shore, above which it rises as a steep cliff, while to the north it extends as a gentle dip slope. As it is composed throughout of this one formation its geological structure is very simple, though it presents several problems of interest of which as yet no complete solution can be offered.

The Carboniferous limestone is one of the best known rocks in the kingdom, partly from its extensive use as an ornamental stone known as encrinital or Derbyshire marble, but mainly from its prominence in so many of our most tourist-haunted landscapes, such as the gorge of Avon, the pass of Cheddar, the dales of Derbyshire, the screes of Llangollen, and the caverns of the Pennines and the Peak. It was deposited in the comparatively shallow and clear sea that succeeded the lakes of the old Red Sandstone and preceded the forests of the Coal measures. The sea seems to have been quiet, and the paucity of mechanically derived sediment indicates that the limestone was deposited at some distance from land, the rock being composed almost entirely of the remains of crinoids,

brachiopods, corals, polyzoa and molluscs. In places beds of chert and sandstone are intercalated, which, though unimportant in the south of England, when traced northwards become more prominent, so that the shale partings of Astbury are the representatives of the 1686 feet of sandstone and shale interstratified with the 470 feet of limestone of Alston Moor.

Puffin Island is a fragment of a wide expanse of this limestone, removed by denuding agencies, which have considerately left this boss severed from the mainland, and thus provided the L. M. B. C. with so comfortable a station. The limestone of which it formed a part now stretches in a narrow band across Anglesey from Malldraeth Marsh to Red Wharf Bay, its course being marked by a series of villages with terrible Welsh names. Another tract ran up the Menai Straits; eastward it must have extended to the Great Ormes Head, and thus have been linked to the wide extent of limestone which passes up both sides of the vale of Clwyd to the large tracts in Flintshire and Denbighshire.

The limestone in the island is a massive grey rock, richly fossiliferous and divided by joint planes into large blocks. It dips as a rule to the N.W.; several dips are marked on the accompanying sketch map of the island. The best sections are those on the north side, below the house, and in the cliff face at the S.W. end; the former shows beds of limestone with thin interstratified bands of shale from half to one inch in thickness, both dipping to the north. The latter is, however, the more instructive, and presents the following section taken in descending order:—

Massive jointed limestone, from top of cliff.

Shaly marl with layers of fibrous calcite $\frac{1}{4}$-inch thick and stained with pyrolusite..... 3 inch.

Limestone	1 inch.
Clay	2 ,,
Nodular limestone	8 ,,
Mottled pyritous shale	3 ,,
Limestone	5 ,,
Pyritous clay with lenticular patches stained purple, yellow and blue	10 ,,
Impure hæmatite or reddle	16 ,,
Nodular limestone, embedded in sandy matrix, stained and cemented by red hæmatite, the nodules increasing in size and number towards the base	16 feet.

Thick massive limestone to base of cliff.

The nodule bed is the best fossil collecting ground on the island, as the fossils have weathered well out in relief and are more easily extracted from these nodules than from the solid limestone. The hæmatite band, of which one specimen yielded 9·2 per cent of iron, can be followed along the cliff till it dips level with the church, below the sea. The limestone itself calls for no special comment as it is of the normal type, but the shale bands demand more attention. Their origin can be regarded either as due to the occasional deposition of layer of shale by the irruption of floods of muddy water into the carboniferous limestone sea, or as due to the accumulation of the insoluble residue of the limestone along the lines of drainage of the water, that percolating through the rock removes some of it in solution as bicarbonate of lime. In many cases, especially in the North, these shale bands are unquestionably due to the former cause, but those on Puffin Island may be regarded with greater probability as analogous to the marl bands of the Chalk, many of which are certainly due to causes operating long subsequently to

the deposition of the beds.* The limestone always contains a certain percentage of insoluble matter such as silica and alumina; Strahan quotes an analysis of the rock from Flintshire which yields ·915 per cent of such material; † that in the Puffin Island limestone I found to vary from ·8 per cent up to as much as 4·23 per cent in a very gritty band pointed out to me by Mr. Lomas. That these shale bands are due to the second cause is shown by their great irregularity and variation in thickness, by their soon thinning out, and by what is more important still, their occurrence on different horizons in the limestone within a few yards of a cliff face. A still more conclusive argument, however, is a thin band that may be seen running vertically through the limestone, and in the absence of shale overlying from which this crack could have been filled, this particular band at least must be due to the second cause. The limestone at the points where these bands occur, shows unmistakeable signs of slight subsidences produced by the removal of some of the rock, which have slickensided the joint planes, and probably also caused the two small faults seen in the N.E. section. One of these has a downthrow to the west of three feet; one further to the west can be traced inland by a series of rabbit burrows which it was suggested to me might indicate the presence of an igneous dyke; a careful search, however, along the line pointed out has convinced me that no igneous rock occurs there, and in fact there is none such on the island, though a dyke occurs in the limestone beyond the life-boat house on the opposite shore.

The purity of the limestone and the severity of the denuding agents to which the islands is exposed accounts for the absence of any soil over much of the island; there

* Kendall, Geol. Mag., 1884, p. 552/3.

† Mem. Geol. Survey: ¼ Sheet, 79 N.W., 1885, p. 10.

are large patches on which there is no grass, and the turf is composed of a thick growth of Armeria maritima; this lack of soil causes the flora and consequently the insect life of the island to be but scanty. Lichens are abundant on the bare limestone, Lecanora parella var pallescens being especially common. For the following list of plants I was able to collect, I am indebted to Mr. R. Paulson:—

Lepigonum rubrum, Fenzl (Spergularia rubra).
Armeria maritima, Willd.
Chrysosplenium alternifolium, Linn.
Sedum rhodiola, D. C.
Crithmum maritimum, L.
Beta maritima, L.
Arum maculatum, L.

Of the relations of the limestone to the beds that preceded and succeeded it, Puffin Island yields no clue; in Anglesey we find it to be underlaid by some 200 feet of irregularly bedded sandstone and conglomerate with nests of limestone, sections of which can be seen in the coast of Red Wharf Bay; this is a subordinate member of the Carboniferous limestone series and is preceded by 600 feet of beds belonging to the Old Red Sandstone, the upper part of which consists of red marls and sandstone with cornstones, while their basement bed is a quartz conglomerate resting unconformably upon the Lower Silurian and Cambrian beds of Anglesey. The limestone series is overlaid by the millstone grit and coal measures, both of which are seen between Malldraeth Marsh and Llangollen, and above these occurs a scrap of Permian conglomerate. Doubtless these latter beds were deposited above Puffin Island, but in the great earth movements at the close of the Paleozoic age the island was raised above the sea and the denudation commenced which has removed any such overlying beds.

Before leaving the Carboniferous limestone it may be as well to attempt to assign the Puffin limestone to its definite horizon in that formation. Mr. G. H. Morton has divided* the series into the following beds, lower brown limestone, lower white limestone, upper white limestone, upper grey limestone, and the fossils of his lists indicate that this belongs mainly to the upper grey limestone, though the upper white limestone is probably also represented. Mr. Etheridge has recorded the following fossils from Puffin Island in Ramsay's "Geology of North Wales." †

Productus giganteus.
,, cora.
Spirifera striata.
,, glabra.
Athyris.
Fenestella.
Glauconome.
Lithostrotion irregulare.
,, junceum.
,, (Lonsdalia) floriforme.
Syringopora ramulosa.

To this list I am able to add the following:—

Campophyllum giganteum, M'Coy (Zaphrentis cylindrica, Scouler).
Amplexus coralloides, Sow.
Lithostrotion martini, Edw. and Haime.
* ,, cæspitosum, Martin.
*Cyathophyllum stutchburyi, Edw. and Haime.
*Cyclophyllum fungites, Flem.
Lonsdalia floriformis, Flem. Zaphrentoid stage.
Syringopora reticulata, Phil.
,, geniculata, Phil.
*Chætetes radians, Fischer.
*Monticulipora (Heterotrypa) tumida, Phil.
*Platycrinus trigintadactylus, Aust.

* Proc. of Liv. Geol. Soc., vol. iii., pp. 176 to 190.
† Mem. Geol. Surv., vol. iii., 2nd edit., p. 259.

Actinocrinus stems.
*Palechinus.
Orthis resupinata, Mart.
Productus semireticulatus, Mart.
,, punctatus, Mart.
,, latissimus, Sow.
*Nucula (Ctenodonta) tumida, Phil. (gibbosa, Flem.)
*Sanguinolites clavus, M'Coy.
*Asymptoceros (Nautilus) dorsalis, Phil.

Succeeding the Carboniferous limestone, there is a great gap in the geological record of the history of Puffin Island, as the only other period represented is the glacial.

Evidence of glacial action may be divided into four classes—external configuration, the presence of erratics, of boulder clay, and of glacial striæ. Of these, boulder clay is absent from Puffin Island, and the evidence afforded by the striæ and the form of the island is not conclusive, so that the erratics, or boulders of rocks foreign to the district, lying scattered over the surface form the strongest argument for glacial conditions. Two of the erratics have been deposited in the laboratory, the larger and better striated of which was identified by Professor Carvill Lewis as a block of Lake district felsite; many small fragments may be collected at the mouths of the rabbit burrows. Mr. J. G. Goodchild, F.G.S., of the Geological Survey, has kindly examined my collection, and has been able to identify the following:—

Hard Chalk of Antrim.
Flints, from Antrim.
Carboniferous Chert.
Ironstone concretion.

* The species marked with an asterisk are not given in Morton's or Etheridge's lists, and apparently have not been recorded before from this district.

Derived from Lake district.	Granite, from Crifell.*
	St. John's Quartz Felsite.
	Tuffs, from different horizons of the Borrowdale Series.
	"Flinty lava and tuff" (Ward), from upper part of Borrowdale Series.
	Ennerdale Syenite.
	Coniston Grit.
	Micaceous shale.
	St. Bees' Sandstone (?).
	Vein Quartz, resembling that of Lake district.
Derived from S. Scotland.	Arkose.
	Greywacke, South Scotch Highlands.
	Felstones, from Kirkcudbright.
	Hornblende Schist with eyes of Quartz, probably from South Scotland.

Though this list contains a preponderance of Lake district rocks, this is due to the greater number of recognizable rocks there, but numerically the Scotch erratics are by far the more important; Mr. Goodchild expressed some surprise at the high percentage of Scotch greywackes and felstones in the collection.

Of boulder clay I have been unable to find any trace, though there is plenty on the adjoining coast of Anglesey, well shown in the cliff sections between Penmon and Beaumaris, where fragments of shells may be found in it.

Glacial striæ were first discovered on the island—at least, I have not been able to meet with any previous record—by Professor Carvill Lewis during the recent visit of the British Association. They were first noticed on a rock surface (since marked with a star of white paint)

* Strahan records Crifell granite from Mold. Quar. Jour. Geol. Soc., vol. xlii., p 380.

about ten yards S.S.W. of the house, where they bear S. 25° W.*; below the house, at a point also marked on the sketch map, other striæ occur bearing S. 20° W., and at one or two other places on the dip slope of the island I found striæ by removing the turf on the north slopes of humps of limestone. The striæ agreed with the general direction of those in the district, which is given by Strahan† as W.S.W., and still more closely with the average in Anglesey, which Ramsay records‡ as 30° to 40° W. of S. The striæ on Puffin are always very faint, but we must remember that they would soon become obliterated on exposed surfaces of this soluble limestone, and that where striæ have been observed on this formation elsewhere, it has usually been on the more durable interstratified grit bands. The approximate parallelism, however, of those on the island clearly indicates their glacial origin.

Surface configuration, which in many places affords reliable evidence of past glaciation, is here of doubtful service, as, though the limestone *massifs* of Puffin Island and the two Ormes Heads are, as Professor Ramsay puts it, "strikingly *moutonnée*," it would not be safe to attach much weight to this argument.

As soon as we leave the record of observed facts for the discussion of their meaning we enter a field much frequented by geological Jingoes, as the form of ice agent that has been here at work has always been hotly contested. The theory that can lay the most valid claim to the palm of orthodoxy is that enunciated by Sir A. Ramsay, in the second edition of his "Geology of North Wales." According to this teacher, great glaciers took their rise in

* The bearings given are magnetic.

† Quar. Jour. Geol. Soc., vol. xlii., p. 381.

‡ Geology of North Wales, 2nd edit., p. 270.

the snowfields of the Lake district, of the south Scotch highlands, and of the north of Ireland, and together filled the Irish Sea by a great *mer de glace* that flowed southwards, glaciating the plains of Lancashire, Puffin Island and Anglesey, on its route to its unknown termination. At the same time glaciers descended from the Snowdon group, through the pass of Llanberris and Nant Francon, and either ended by expanding over the plain between the hills and the shore, or joined the northern ice on the line of the limit of the northern drift, as shown in Strahan's map.* Under the ice sheet the boulder clay and other deposits are supposed to have been formed as a ground moraine. One of the effects of the passage of this ice sheet over Anglesey was, according to Ramsay, the erosion of the parallel valleys of the Menai Straits and that between Pentraeth and Malldraeth Marsh, which are thus regarded as but large glacial grooves; Professor Seeley, however, demurs to this view,† and prefers to consider the former as a sort of *cañon* due to solution and denudation of the carboniferous limestone that once filled it. Succeeding this great ice sheet, a warmer interglacial period is supposed to have followed, during which the shell bearing sand of Moel Tryfaen, so well known since its original description by Trimmer,‡ was deposited at the height of over 1350 feet above the present sea level. Colder conditions again prevailed, during which local glaciers filled the valleys of Cumberland and Snowdon.

But recently a strong current of opinion has set in against this interpretation of our glacial deposits, led off by Mr. Belt's series of letters to "Nature" (vol. x., 1874), and by Mr. Goodchild's advanced and suggestive paper on

* Quar. Jour. Geol. Soc., vol. xlii., p. 370.

† Phillip's Geol., edit. 1885, vol. i., p. 129.

‡ Proc. Geol. Soc., vol. i., p. 331.

"The Glacial Phenomena of the Eden Valley and the Western Part of the Yorkshire Dale District,"* and now vigorously supported by Professor H. Carvill Lewis of Philadelphia. If the views of this new school be adopted, the complicated system of successive glaciations with intervening warmer periods becomes unnecessary, nor is required the great submergence of 1400 feet. According to this theory, advanced by Professor Lewis, there was at the last glacial period (as previous glaciations of a much earlier date are admitted)† a subsidence of 500 feet in North Wales and 200 feet in the Lake district, the Irish Sea being filled by the glaciers that issued from the Cumberland hills, the Firth of Clyde and the north of Ireland, and the ice sheet flowing southwards glaciated Puffin Island and Anglesey, and deposited along its course boulders of greywacke and felsite from the north, flint and chalk from Ireland, and shells from deposits in the Irish Sea. The ice becoming packed against the Welsh hills, was forced up their flanks in one place to the height of 800 feet, and there deposited the shell drifts of Moel Tryfaen. As the glacier dwindled before the approach of a warmer climate, which effectually repealed this ice union of the three kingdoms, its detritus was deposited, according to Professor Lewis, as a great terminal moraine which followed the ice sheet during its retreat northwards; Mr. Goodchild, however, denies the existence of any such moraine, and considers that the deposits were dropped simultaneously over a large area from the slowly melting ice. At the same time, in the east of England, the great chalky boulder clay was formed, according to Professor Lewis, in a great extra moraine lake which extended from

* Quar. Jour. Geol. Soc., vol. xxxi.; and Trans. Cumberland and Westmoreland Assoc. for Adv. of Science, no. xi., 1887.

† Geol. Mag., 1837, p. 516.

the Humber to the heights overlooking the valley of the Thames; to this view there are, however, serious objections, and the chalky boulder clay was probably formed by the melting of the southernmost tongue of ice at a period somewhat earlier than the explanation would admit. The theory of extra moraine lakes, due originally to Belt, has been applied with greater probability to the drifts of the valley of the Thames.*

To this theory probably the greatest objection is that it postulates the power of ice to ascend 800 feet, to which the deposits are lowered by the admitted submergence of 500 feet, and this many English geologists declare to be impossible, or at least unproved. In this case it is of course useless to cite, as some objectors do, the Swiss glaciers in their present development, as they do not represent conditions analogous to those of an ice sheet such as we have here to consider. It must be admitted that there is no well authenticated case of an ice sheet to-day ascending slopes for any considerable distance; in Greenland such probably occurs, as in the opinion of the Danish explorers the country is saucer-shaped, consisting of a deep central depression surrounded by a border of mountains over which the ice has to ascend during its route to the sea. That ice has done so in the past, is more easily proved, *e.g.* by the case of the old Rhone glacier, or to cite an English case, that described by Mr. Goodchild in his paper on the Eden valley, where blocks of "brockram," a breccia peculiar to the valley below the 700 foot contour, have been carried across the Stainmoor Pass, over a height of at least 1350 feet, while other rocks have been carried up for over 1000 feet. Belt has called attention ("Nature," vol. x., p. 63) to an admirable instance of this action within the L.M.B.C.

* Goodchild, Proc. Geol. Assoc., vol. ix., pp. 155 and 156.

district, which has been recently re-investigated by Professor Lewis. South Barrule is a limestone hill in the Isle of Man, four and a half miles north of Castletown; it is 1585 feet high and glaciated to its very summit, close to which occur boulders of granite from a boss 760 feet high, a mile and a half to the E.N.E.; thus here we have a proof of an elevation of ice-borne boulders of 825 feet within a mile and a half, or 950 feet to the mile. Similar cases could easily be multiplied, as that quoted by Professor James Geikie* from Sörnebohm, in which blocks occur 4500 feet above the sea which are not known in situ above 1800 feet. The objections to the explanation of these phenomena by floating ice are well summarized by Geikie in this paper. Thus there seems no insuperable difficulty in the ascent of the ice up this comparatively trivial slope, and especially when we remember that the ice sheet was probably 1200 feet or more thick, so that it merely lapped against the side of the hill, and the upper layers of ice rode over it.

The great argument for the submergence has, however, always been the Moel Tryfaen fossils, whose evidence seems considerably overrated. The shells are rare and fragmentary, and many collectors who have visited the section have returned without a single specimen, and even men who have devoted some time there have been rewarded by but a few fragments which could only be identified by a trained specialist. The lists include a motley collection from every zone and depth; there are shells so littoral as Mytilus edulis, Cardium edule, Littorina littorea, and especially Littorina rudis, which is expressly regarded by Gwyn Jeffreys† as characteristic of

* Note on the occurrence of erratics at higher levels than the rock masses from which they have been derived. Trans. Geol. Soc., Glasgow, vol. iv., p. 235.

† Brit. Conchology, vol. i., p. 104.

the very highest littoral zone. The laminarian zone is represented by Trochus magus, Cyprea Europea, Cyprina Islandica, &c.; the coralline and deep sea by Trichotropis borealis, Trophon clathratus var. Gunneri, Aporrhais pes-pelecani, Venus gallina var. Striatula, and Venus carina. Probably still more important a point is that so many zoological provinces are represented in this deposit; the Norwegian, Boreal, Lusitanian and Celtic provinces, all contribute to the Moel Tryfaen beds, and renders it almost impossible that they can have been deposited in situ.

A comparison of the shells of this deposit with those of the unquestionably marine drifts of Wellington or South Lancashire, brings out features of marked difference; at Wellington a handful of good shells can be picked out in a few minutes, while at Moel Tryfaen you might sift for an hour and not see one; moreover, the lithological characters of the two sets of beds present important differences. It may be advisable to note in this connection that so cautious a geologist as Mr. H. B. Woodward has recently contended* for the similarly *remanié* nature of the shells of the Norfolk drifts. A further point that makes for the same conclusion is derived from the condition of the shells from the high level drifts of Ballymonduff and Caldbeck Castle, south of Dublin; † when recently examining the collection of shells from these deposits in the possession of the Rev. Maxwell Close, I was much struck by their resemblance to those of Moel Tryfaen, and especially by the fact that those from the greatest heights were always the more rolled and fragmentary, obviously implying that they had been carried up by some such agent as ice

* Proc. Geol. Assoc., vol. ix., p. 114.

† See Maxwell Close, Jour. Roy. Geol. Soc., Ireland, vol. iv., new ser. (1874), pp. 36 and 37.

The view that these deposits were formed by icebergs stranding on the hill, is open to serious objections, since the bed is on the lee side where such stranding could not occur, and the terminal curvature of the slates on which the sands rest curve down the hill, as Professor Bonney pointed out, and thus could not have been so caused. The beds, moreover, are much contorted, in a manner very suggestive of the action of land ice. The strongest objection, however, is that a submergence to this depth would have left far more conspicuous traces than actually occur, as it could not have failed to have swept away many of the light drift beds of the district, and would have left more marine beds in the hollows of the Welsh hills, in which such would have been so readily deposited, and so admirably sheltered and preserved.

Having thus seen that the marine origin of the Moel Tryfaen drifts is improbable, alike from the distribution of the beds, their lithological characters, and their fossil contents, it remains to consider the alternative theory of their deposition. It is one of the best known facts of glacial motion, that the lowest layers have a constant tendency to work their way up to the surface, carrying with them any boulders they may contain. Whatever theory we may adopt to explain this, the fact remains that under the combined influence of ablation and turgesence the boulders will rise to the surface; hence as the ice sheet flowed over the Irish Sea, it picked up flints, shells, &c., which would probably freeze together into boulders, and so work their way up through the ice to a level from which, on the melting of the ice sheet, they would be deposited on the neighbouring hills.

It must of course not be forgotten that though these views are steadily gaining ground, the balance of opinion at present favours the older theory, and therefore these

modifications can only be accepted with caution, and advanced with the deference due to the geologists opposed to them. But if the supposed submergence be abandoned, a great step will have been taken in the simplification of the interpretation and correlation of our glacial deposits, though they may yet be more complicated than Professor Lewis admits. If so, the lower boulder clay of North Wales, the Arenig drift of Professor Hughes, formed at the period of most intense cold, may have been synchronous with the deposition of the Bridlington beds, as Professor Hughes suggests,* a conclusion that thoroughly harmonizes with Mr. Mellard Reade's contention,† that the east coast was submerged before the west, and that before the latter was effected the most severe conditions had passed away.

Of the age succeeding the glacial epoch, as far as Puffin Island is concerned, we know but little. Man then settled in the district, if he had not done so before, as Dr. Hicks would have us believe. I know of no trace of man's presence on the island older than the church, which tradition says was built before the connection with Anglesey was severed, and though I have not met with any historical records on the subject, it is not improbable that such was the case. The Sound runs along a slight synclinal axis, and this depression may have guided and assisted the denuding agents; the limestone was probably removed during the glacial period, and the strait filled up with detritus which would be easily removed. The main current through the Menai Straits would then flow through it, and the sands, washed from the glacial deposits that had choked up the straits, would be deposited in the quiet water under Penmaenmawr, and thus would have been

* Quar. Jour. Geol. Soc., vol. xliii., pp. 78 and 88.

† Proc. Liv. Geol. Soc., vol. iii. (1874–75), p. 43.

accumulated the Lavan Sands. During this period the ordinary denuding agents gave the finishing touches to the scenery of the district, supplementing the volcanoes that had built up the mountains, and the glaciers that had eroded the valleys.

In conclusion, therefore, let us glance at the splendid geological panorama to be seen from the south-west end of the island, by the old flagstaff. To the east may be seen the limestone *massif* of Great Ormes Head, once united to Puffin Island, and thus to the bare undulating limestone hills of Anglesey that bound the horizon to the west. Southwards, beyond the Lavan Sands, towers the quarry-terraced cliffs of the bronzite felsite of Penmaenmawr, to the west of which extend the heather covered gullied slopes of the lower Silurian rocks that form the Caernarvonshire range. Still further westward, behind the town of Bangor, can be seen the old ridge whose age has been so keenly contested by Ramsay, Hughes, Hicks, Bonney, Roberts, and many more. Beyond can be seen the mass of lavas and volcanic ash that form the peak of Snowdon. This view affords an admirable summary of the past history of the district from the old Twt Hill to Bangor ridge, the Cambrian of Anglesey, the lavas of the lower Silurian, and the limestone of the Carboniferous, to the glacial drifts that line the shore, and the still accumulating sandbanks that will silt up the Menai Straits, just as a neighbouring estuary within no distant date has given place to the fertile meadows of Malldraeth Marsh.

NOTES on a TRACT of MODIFIED ECTODERM in *Crania anomala* and *Lingula anatina*.

By Alice Heath.

With Plates III., IV. and V.

[Read 10th December, 1887.]

The interest attaching to the Brachiopoda is so great, and touches the naturalist at so many points, as to be an ever present excuse for studying them with care and in such detail as is possible. The mere fact of their enormous distribution in time is of itself very fascinating; whatever modifications may have taken place in the softer tissues the skeletal portions have been most persistent in many forms which have survived to the present time, while the close resemblance of many living forms to one another points to but comparatively slight individual variation since the early Brachiopoda separated from the main invertebrate phylum. The homologies of the different organs with those of other invertebrate forms is of great interest, and has received attention from various investigators. In one way and another Brachiopods claim attention on various grounds, and, to judge by the mass of literature on the subject, they have been very fairly worked at.

With regard to *Crania*, in particular, comparatively little detailed work seems to have been done until quite lately; in 1886 the results of some very careful observations made by M. Joubin, at the marine laboratory of Banyuls-sur-Mer, appeared in the "Archives de Zoologie Expérimentale."* This paper is prefaced by a detailed

* Sér. 2e, tome iv., p. 161.

bibliography, which, although it does not pretend to be exhaustive, mentions apparently all the more important works; references to all important papers may also be found in Davidson's "Monograph of the Brachiopoda," now being published.*

When I first saw M. Joubin's paper, I felt that it was almost impossible but that he had more than covered the observations on *Crania* and *Lingula* which I had been making recently; but slight differences in method are often sufficient to bring histological details to light, and it is only on such points of detail that I can claim to carry on the work of my predecessors just one step farther. Considering the work which has already been done in that field, it will not be necessary, I think, to go into anatomical minutiæ further than is needful for the understanding of the special remarks which I have to make.

I may state that the method followed throughout has been simply to decalcify the specimens, to stain with either alum carmine or with picro-carmine, and to sectionize the whole animal. The results of staining with picro-carmine have been decidedly more satisfactory than those obtained with alum carmine, the tissues as a whole appear clearer and the differentiation is more complete. The sections made have been both longitudinal and transverse.

GENERAL ANATOMY.

In *Crania* and *Lingula* the soft tissues are completely enclosed between a pair of shell valves, placed dorsally and ventrally (see Pl. III., fig. 1); in *Crania* the animal is attached to foreign bodies by the whole surface of the ventral valve, in *Lingula* by a stalk (Pl. IV., fig. 4). The shell in both is lined with and secreted by the mantle with

* Vol. vi., Palæontographical Society, London, 1886.

which it is in close connection. On removing the shell the body is seen to be composed of two distinct portions.

(*a*) The pallial chamber, which occupies the larger and anterior part of the body, communicates freely with the exterior, and contains the arms. This chamber is separated posteriorly from the visceral cavity by a firm body wall which is continuous with the dorsal and ventral lobes of the mantle; when the shells are closed the margins of the mantle touch, and the pallial chamber must be shut off from the exterior.

(*b*) The visceral cavity. Posterior to the pallial chamber there is a relatively small chamber, in which are placed (1) the digestive organs, *i.e.* the alimentary canal and a large glandular organ communicating with it; this is suspended in the cavity and connected with the body-wall by a membrane which may be termed the mesentery; (2) portions of the reproductive organs; (3) the muscles which move the shell.

The Arms form a very prominent feature of the pallial chamber (Pl. IV., figs. 2, 3 and 4), and call for some description. They are attached to and in structural connection with the anterior body wall from the median line to some distance on the right and left (see Pl. IV., fig. 4); from their base they are continued laterally and posteriorly, then make one large coil anteriorly and medianly, followed by several smaller coils in the same plane. From base to apex the arms are provided with a fold and a double row of alternating tentacles (Pl. II., figs. 2, 3 and 4); the fold is always dorsal to the tentacles. The base of the arms is pierced by the œsophagus. In the arms there are three sets of canals (see *Lingula*, Pl. III., fig. 2; *Crania*, Pl. III., fig. 3).

(*a*) A canal containing the brachial muscle, which communicates with the tentacular canals.

(*b*) The tentacular canals.

(*c*) A canal parallel to (*a*), and apparently empty.

The large canals (*a*) and (*c*) have no communication with one another, except so far as they both open into a system of lacunæ in the œsophageal region.

Nerves.—With regard to the nervous system, I must refer to M. Joubin's paper. He advises staining the tissue to be observed with methyl green and borax carmine, making transparent with glycerine, and subjecting to pressure. This method he considers preferable to the observation of sections, the results appearing to him more satisfactory. After giving some account of the nervous system in general, he describes as a ganglionic plexus a system of nerves and nerve cells running throughout the length of the arms parallel to the large canal containing the brachial muscle, and giving off nerves in many directions, but especially to certain regions of the fold and tentacles, where the epithelium is seen to be deeper than elsewhere.

THE TISSUES.

There are two systems of tissue which call for special notice; these are the epithelial and sub-epithelial tissues.

The sub-epithelial tissue is remarkably constant in structure throughout the whole body, but its development in thickness is extremely varied; it may be a very thin and fine plate, as in the greater part of the alimentary canal; or it may be thick, firm and elastic, as in the arms (see Pl. III., figs. 2 and 3). It is continuous in the arms, mantle, body-wall, alimentary canal, "liver," and mesentery (see Pl. IV., fig. 1), and a tissue not distinguishable from it forms, what for want of a better name I must call, the muscle terminations; this last seems to be the only case where this tissue is not continuous, it occurs as a

thin plate or system of plates, separated from the body-wall by short muscular fibres, which, however, do not appear to pass through the plates (Pl. IV., fig. 1). The sub-epithelial tissue stains readily with either picro or alum carmine. In the arms this tissue is usually spoken of as the cartilaginous skeleton ; it forms the great mass of the arms ; it is pierced with the canals already referred to, and in some parts, notably in the region of the mouth, it may almost be said to be riddled with holes in addition to those spoken of as the œsophageal lacunæ of the arms ; these I believe to be simply due to the method of preparation, and probably represent cavities resulting from decalcification. I am led to suppose that this is so from the fact that these tiny holes are not lined with an epithelium, as all the larger ones are. With the exception of the arms, the sub-epithelial tissue appears to be everywhere perfectly homogeneous ; so far as I have observed there are neither fibrillæ nor cells to be seen anywhere. In the arms, however, there is apparently an exception to this rule ; fibrillæ and cells are abundant, and the fibrils often appear to be connected with the cells, and to follow certain more or less definite paths (see Pl. III., figs. 2 and 3). At first I imagined that these cells were of the nature of cartilage corpuscles, and that the fibrillæ were in some way connected with them ; this explanation, however, I abandoned, and from the fact that the fibrillæ were constantly seen to abut upon a region of modified epithelium placed upon both the inner and outer sides of the base of the brachial fold, I was inclined to look upon them as nervous in nature, and when I found that recent observations had traced the brachial nerve plexus to a similar position, I did not hesitate to consider them to be the same structures. The question then naturally arises, are these fibres actually connected with the tract of modified epithe-

lium, and if so, in what manner are they connected? To answer this question, some description of the epithelium is necessary.

The epithelial tissues.—There are three well marked varieties of the epithelial tissues to be observed in *Crania;* these are :—

(*a*) The epithelium of the body cavity generally, seen in the cavities of the arms, on the mesentery, and on the inner surface of the body-wall; it is squamous in character, and calls for no further comment.

(*b*) The epithelium of the alimentary canal. In the anterior region it is very fine, deep, and with an undulating free margin. In the posterior region it is narrower, and approaches in character the columnar cells of the epidermis. It is continuous with the epithelium of the liver (which is nothing more than a follicular diverticulum of the alimentary canal).

(*c*) The epidermis. This is columnar over the whole of the pallial chamber, that is on the inner surfaces of the mantle and over the arms. The cells are distinctly columnar throughout the whole area, but show certain modifications in particular regions. On the mantle, much of the body-wall, and those parts of the arms farthest removed from the fold and tentacles, it consists of short columnar cells with a distinct nucleus, the whole staining fairly well, but with a tendency to stain less deeply where attached to the sub-epithelial tissue.

The epithelium is modified on the arms, over the whole of the sides of the tentacles and the fold which lie next each other, and at the outer base of the fold, close to the large empty canal. In much of this area the epithelium differs simply from that of other areas by being deeper, the cells being long and rather narrow; but in the areas of special modification there is a groove in the sub-epithelial

tissue, in which the modified portion rests (Pl. III., figs. 1, 2, 3, *x.*, *x.r.*); the epithelium is not only much deeper, but the epithelial cells may be seen frequently to end below in long colourless tails or threads, which are in connection with a mass of tissue lying below them, and on the outside of the sub-epithelial tissue. This mass consists of stellate cells (Pl. IV., fig. 5, and Pl. V., figs. 1—4); the nucleus and nucleolus stain deeply with picro-carmine, but the outer part of the cell is colourless and hyaline; the points of the stars are produced into long colourless threads connected in some cases with the threads from the outer columnar cells; many appear to be lost in the section, *i.e.* they pass out of the plane of the section, and some leave the epithelium in a group, and enter the sub-epithelial tissue as a bundle of fibres (Pl. IV., fig. 5, and Pl. V., figs. 1, 2 and 4). The bundles sometimes pass for some distance through the epithelium before leaving it (Pl. V., fig. 4); they appear to enter the sub-epithelium only where the channels are deepest. The channel on the outer aspect of the fold is deeper than the one on the inner side. These fibres certainly pass through the sub-epithelial tissue from one to the other of the two areas of modified tissue on the opposite sides of the fold, and also to the empty canal, which they may be seen to enter (Pl. III., fig. 3), and although I cannot trace them continuously, solitary fibres, I believe, pass through this bundle to the deep epithelium at the base of the tentacles. The modified epithelium on the outer aspect of the fold extends apparently from the apex of each arm to its base, but it does not quite reach to the region of the mouth on either side; the normal columnar epithelium gradually taking the place of the modified portion. The modified epithelium, between the fold and the tentacles, is only observable in the free portion of the arms, and cannot be

detected in the parts attached to the anterior body-wall. An exactly similar mass of tissue may be found on the ventral body-wall on either side of the median line; it differs only in its greater development from the modified epithelium of the outer aspect of the fold. The cells are most numerous in its peripheral portion, the part nearest the sub-epithelial tissue consisting almost entirely of fibres running in all directions. When in a section many of these fibres are cut across, they give rise to a granular appearance. Although I have looked through my sections, I have not noticed any fibres given off from it, either singly or as a bundle, but whether that is from want of care in observation, or from defective preparation, I am unable to say.

It is interesting to compare the condition of this modified epithelium in *Crania* with the corresponding tissue in the arms of *Lingula anatina*. From the greater size of the animal it is there larger and easier of detection. The cells and fibres throughout the cartilage are very numerous (Pl. III., fig. 2). There are three regions of especially modified tissue on the arms; one at the outer base of the fold, large and deep (Pl. III., fig. 2, *x.*); this is connected with the epithelium of the tentacles by fibres passing from one to the other; the fibres from the fold enter the epithelium of the tentacles and pass as strands along its length (Pl. V., fig. 1). Another mass of tissue may be found on the "posterior" or "lateral" canal (Pl. III., fig. 1, *x.1.*); it is shallow and but slightly developed, except at the base of the arms, and it is only in the latter region that fibres pass from it into the sub-epithelial tissue, and thence to the brachial muscle, where they become lost (Pl. III., fig. 1 *x.1.*, and Pl. V., fig. 2, *n*).

A corresponding tract of tissue does not apparently exist in *Crania;* and neither of the masses described in *Lingula*

seems quite to correspond to the great ventral mass in *Crania*. In *Lingula*, besides the tracts of specialised tissue, individual epithelium cells may sometimes be seen to give off fibres which enter the cartilage, more especially in the region of the brachial muscle.

These tracts of modified epithelium are apparently the same as those referred to by M. Joubin in *Crania* as being probably sensory in function, and possibly they correspond to the tracts of specialised tissue mentioned by some authors as occurring in some of the articulate Brachiopods and referred to as sense organs. The desirability, if not the necessity, of some means of testing the quality of the sea water, both for respiratory and nutritive purposes, is obvious, and the position of this modified ectodermal tissue on the delicate tentacles and the fold of the arms, in intimate connection with nerve fibres and cells, points I believe conclusively to its sensory nature.

Explanation of the Plates.

f. brachial fold; *t.* tentacle; *b.t.* bases of tentacles; *n.* nerve; *ep.* epithelium; *s.ep.* sub-epithelial tissue; *c.m.* brachial canal containing muscle; *œ.* œsophagus; *d.s.* dorsal shell; *v.s.* ventral shell; *p.c.* pallial chamber; *l.m.* mantle lobes; *w.v.c.* wall of visceral chamber; *o.m.* oblique muscle; *m.* muscle in canal; *m.s.* mesentery; *x.*, *x.1.* modified epithelium; *P.* posterior; *A.* anterior.

Plate III.

Fig. 1. Transverse section of *Lingula anatina*, along line *a*...*b*. of Pl. IV., fig. 4, half shown.
Fig. 2. Transverse section of the arm of *Lingula anatina*.
Fig. 3. Transverse section of the arm of *Crania anomala*.

Plate IV.

Fig. 1. Longitudinal section of *Crania anomala*, along lines *P*...*A*. of figs. 2 and 3.
Fig. 2. *Crania*. Pallial chamber showing arm (half drawn), dorsal mantle lobe removed.
Fig. 3. *Crania*. Pallial chamber showing arm (half drawn), ventral mantle lobe removed.
Fig. 4. *Lingula*. Pallial chamber, ventral mantle lobe reflexed.
Fig. 5. *Crania*. Pl. III., fig. 3, *x.* enlarged.

Plate V.

Fig. 1. *Lingula*. Pl. III., fig. 2, *x.* enlarged.
Fig. 2. *Lingula*. Pl. III., fig. 1, *x.* enlarged.
Fig. 3. *Lingula*. Pl. III., fig. 2, *x.1.* enlarged.
Fig. 4. *Crania*. Pl. III., fig. 3, *x.1.* enlarged.

On the TERMINOLOGY of the REPRODUCTIVE ORGANS of PLANTS.

By R. J. Harvey Gibson, M.A., F.R.S.E.,
LECTURER ON BOTANY IN UNIVERSITY COLLEGE, LIVERPOOL.

[Read 10th December, 1887.]

Probably one of the most important of the many results which have followed from the acceptance by biologists of the doctrine of evolution has been the closer union of the two sub-sciences of Botany and Zoology. For I am disposed to think that those who, like Dr. Woodward,* consider that "Biology replaces in name only, without any substantial gain, the hitherto better known sciences of Botany and Zoology," have failed to grasp that that union in name is the outward sign of the adoption of a unity of treatment in the investigations into the morphology and physiology of plants and animals, a step, I think, parallel to, and naturally following from, the discovery by Max Schultzė of the identity of Dujardin's "sarcode" with Von Mohl's "protoplasm." Will any one affirm that the employment of one term to designate "the physical basis of life" in animal and plant has not been a substantial gain?

The science of Biology is thus of comparatively recent growth, although the term has itself long been in use to signify the conditions of life and habits of an organism, whether plant or animal. Now, however, when we know that plants and animals are not only built fundamentally on the same great principles and formed out of the same

* Presidential Address to the Geological Section of the British Association Meeting of 1887.

substance, protoplasm, but that they are also governed by the same laws in their distribution in space and time, and have arisen by modification from a common type, we are surely justified in employing the term Biology in its wider signification only, and in uniting under it the entire range of subjects treated of by the sub-sciences of Botany and Zoology. These two sub-sciences are in fact not independent but complementary, the methods employed in either are the same, the general conclusions deducible from their study are fundamentally alike.

And yet, until quite recently, Botany has lagged behind the sister science, especially in that department wherein Zoology has made so great progress, viz. etiology. Numerous attempts have been made to arrive at some definite conclusions with regard to the path along which the animal evolution has passed in its progress from the unicellular protozoon to the complex multicellular mammal, but few botanists have attempted to unravel the genealogical relationships of the numerous tribes of plants. Professors Marion and De Saporta* are the most noticeable exceptions, and their work has scarcely done more than raise a storm of destuctive criticism. If we seek for the reason of this feature in botanical history, I think it will not be difficult to trace it to the want of that thorough comparative morphological knowledge among botanists which zoologists possessed as a result of the labours of the morphological school founded by Cuvier and carried on with so great success by his pupils. Not only so, but the almost complete ignorance which until quite recently prevailed even among the leaders in the science of the life histories of the lower plants, and of the meaning of the various stages through which they passed, prevented even a guess being made as to the signification of the phenomena

* L'Évolution du Règne Végétal. 3 vols., Paris, 1881.

of reproduction in the higher plants. The very names "Phanerogamia" and "Cryptogamia," given to the higher and lower plants respectively, implied an entirely false conception of the nature of the parts on which that terminology was based.

Despite the great progress which has been made within the past few years by Hofmeister, Sachs, Goebel and others, the terminology of Botany leaves yet much to be desired.* Many old terms have, it is true, disappeared, but there are many more still which show no signs of yielding up the places they have so long occupied; whilst the introduction of a host of new terms, often bearing a strong mimetic resemblance to their predecessors, has tended to produce rather confusion than lucidity.

There have not been wanting critics who, foreseeing the difficulties in the way of obtaining clear notions of great morphological or etiological problems with the clumsy and often misleading terminology in use, have made an effort to reduce the chaos to something like order. But what botanists like Murray and Bennet† achieved in this line, for example, in the use of the term "spore," has just as often been undone by the adoption of views like those

* "The task of explaining the connection between the several groups has been rendered difficult by the present state of the terminology, which is one of transition. We may hope, however, that the terminology will soon be greatly simplified and cleared up by applying the acknowledged homologies. . . ."—Goebel, *Outlines of Classification and Special Morphology of Plants*, p. 7. Clarendon Press, 1887.

"The sexual organs are male and female; the male organs produce zoosperms (antherozoids), the female organs oospheres. In the present state of science it would therefore be the simplest and most accurate plan to denote all male organs spermogonia and all female organs oogonia, in contrast to the sporangia which produces asexual reproductive cell-spores."—Sachs, *Lectures on the Physiology of Plants*, p. 742. Clarendon Press, 1887.

† A Reformed System of Terminology of the Reproductive Organs of the Thallophyta. Q. J. M. S., vol. xx.

recently advocated by Vines,* in distinguishing two kinds of spores, sexual and asexual.

To my mind much of the virtue of such critical surveys is lost in the semi-conservative tendency of the proposed alterations. In the following remarks I have endeavoured to make a few suggestions, which, without being dogmatic, I think afford an indication of the form which this much needed revision in terminology must take.

In the first place, I would suggest that similar structures in plants and in animals should in all cases be known by the same names, and that these names should be retained throughout. Alternation of generations, with its curious phenomena of sexual and asexual organisms, occurs both amongst plants and amongst animals, although it is among the former that it attains its greatest importance. The medusoid with its reproductive organs is exactly comparable to the thallus of a fern or of a moss with its so-called antheria and archegonia. Indeed the comparatively higher organisation of the medusoid over the hydrozoon, is further paralleled by the correspondingly higher development of the moss-thallus over its parasitic asexual progeny. In botanical terminology two new names have been lately introduced to distinguish the sexual from the asexual generation, namely "oophyte" and "sporophyte." The former term I do not think can be looked on as perfectly satisfactory; for "oophyte" is applicable only to a thallus bearing female reproductive organs. Gamophyte, on the other hand, would, I think, be applicable to a male, a female, or a hermaphrodite thallus.

Generally speaking, we may say that the vast majority of plants and animals, at some period of their existence, develope two kinds of sexual cells, male and female. In

* *Physiology of Plants.* Cambridge Univ. Press, 1886.

Zoology we are accustomed to name these sexual cells spermatozoon and ovum respectively. The corresponding cells in plants have, however, received names without number. "Spermatozoid," "antherozoid," "male gamete," "microzoospore," "spermatium," for the male; "oosphere," "macrozoospore," "germinal cell," "oogonial cell," "archegonial cell," for the female, are only a few of the terms even now in use in ordinary botanical text-books. Why not call the male cell by a term which it shall retain under all circumstances, and the female cell by a similarly unchangeable name? What zoologist would dream of calling the female sexual cell of a Sponge an ovum, and that of a Crustacean or a Tunicate an oosphere or a germinal cell?

Before deciding what these two important cells should be called, let us briefly enquire whether the terms in use in Zoology are suitable in all cases. So far as "ovum" is concerned I think no fault can be found, and I would propose to give that name to the female sexual cell in all plants and animals whatsoever, that is to say, to the cell which, when fertilized, becomes by segmentation the mass of cells destined to form the new plant or animal. With regard to the term "spermatozoon," there is one objection, namely that the addition of the word "zoon" suggests, if not an animal affinity, at least the possession of the power of movement as one of the characteristics of the male reproductive cell. Now many spermatozoa even in the animal world do not exhibit movement, and motile male cells in the plant world are not found in very many groups. This difficulty could, however, be easily got over by dropping the affix "zoon," and calling the male cell simply a "sperm."

Again the ova and sperms are formed in certain organs to which names must be given. "Ovarium" and "sper-

marium" seem to be terms perfectly applicable to all forms of the female and male organ respectively. In some cases the ovarium, or the spermarium, will be found to be simple in its structure, as for example in an Alga or a Sponge; in other cases complex, as in the majority of animals. Again, it may be degenerate and rudimentary, as in the Phanerogams; or indistinguishable from the ovum, as in some of the higher Fungi. In all cases, however, the organ, whether male or female, whether simple or complex, can be reduced to the primitive type, viz. a sac or tube, the contents of which remain unmodified, forming undifferentiated male or female protoplasm (Conjugatæ, e.g. many Fungi), or become modified into two or more ova or sperms. If we were to follow out this principle all such terms as testis, oogonium, archegonium, &c. would disappear. The organ would, in all cases, be an ovarium or a spermarium, greatly modified it might be, but still a modification of the type, and to be designated by the term applied to the type, with or without a qualifying phrase, according to the degree of variation in the case in question. The gain to students of comparative morphology would under these circumstances be very great, for at present homologies are completely hidden by the terminology in use.

The ovum when fertilized by a sperm is undoubtedly a potential plant or animal of the species to which the parent or parents belong. Why should this product of sexual union be called a "zygospore," an "oospore," or a "carpospore," when surely no other term is applicable than "embryo?" The moment the act of fertilization is completed the ovum becomes an embryo, capable of development at once, or after a period of rest.

We now come to the use of the term "spore" in Botany, and probably no term in the whole range of botanical

phraseology has caused so much trouble as this one. It has always been acknowledged that plants reproduce themselves sexually and asexually. We have just seen that the union of the sexual cells results in the formation of an embryo. The signification of the process of union is one on which there are still many diverse opinions. Probably that which accords best with the facts of the case is, that the ovum and the sperm are imperfect, or rather complementary cells, each possessing what the other wants, to make it a complete and perfect cell capable of forming an embryo, and each therefore incapable of becoming such without union with the other. I do not propose to enter here into the discussion of the functional differences between these cells, or the way in which it has come about that the sperm has become so differentiated in character from the female cell, loosing very early the power of receiving a sexual stimulus from other non-sexual cells, and so developing into an embryo, a power retained by not a few ova, according to the researches of Jaworowski* and others.

Many plants are, however, able to effectively reproduce their kind by giving rise, in a variety of ways, to apparently perfect cells, which without union with any other cells are able to develope into plants like their parents. Such cells almost all botanists have agreed to call "spores," or asexually-formed cells. Vines, however (*loc. cit.*), as already stated, considers that these cells are entirely comparable to the fertilized ova, and therefore describes spores as of two kinds, asexual and sexual, describing the product of union of an ovum and a sperm as a sexually-formed spore. There can be no doubt that an embryo or fertilized ovum is physiologically equivalent to a spore, inasmuch as both are capable of forming an adult plant; but surely

* *Archives Slaves de Biologie*, 1886.

that physiological equivalence is not sufficient to overbalance the great morphological differences implied in the origin and mode of formation of the so-called sexually-produced spore. Moreover, even looked at physiologically, the very fact that sexual reproduction does occur, and that too at critical periods in the life of many forms, and that the spore produces sooner or later a gamophyte, while the fertilized ovum produces a sporophyte, surely points to the supreme importance of the sexual origin of embryos, and the fundamental difference between such a product and a spore. It is to the organs of reproduction in plants that we must go in the first instance for a clue to their genetic relationships. In the animal world, one might almost say, the evolution has been an evolution of organs connected with the maintenance of individual life, whilst in the plant world the evolution has been one of the organs connected with the maintenance of tribal life. We may perhaps look on this fact as affording some clue to the relatively higher organisation of the animal, and its continued individual evolution accompanied by the marked decrease in its reproductive powers. The plant on the other hand shows comparatively low individual organisation, but vast powers of multiplying its kind. For these reasons alone I would be disinclined to accept Vines's use of the term "spore." The obvious confusion which must necessarily arise from the application of the same term to two products so different in their origin and morphological and physiological value in itself forms no slight objection to this terminology. By a spore then I would indicate the physiologically perfect cell which may be separated from a plant, and which, without union with any other cell, may become under suitable conditions an adult organism. Naturally this exclusive use of the word spore would form

another reason for the abolition of the compounds of it, such as "oospore," "carpospore," and the like.

Spores again are produced in sporangia, which are in turn developed on sporophylla upon a sporophyte.

Having laid down these fundamental principles it behoves us to see how the various modifications of the type can be reduced to order. In doing so it will be necessary to bear in mind the two peculiar phenomena of apospory, or the disappearance of the asexual method of reproduction, and apogamy, or the disappearance of the sexual method.

In order to illustrate the use of the terms, the adoption of which I am advocating, no better example can be taken than the Fern. In that type we have a typical life-history where all the essential stages are developed. An ovum (oosphere) is developed in an ovarium (archegonium), and a sperm (antherozoid) is developed in a spermarium (antheridium) on the same gamophyte (prothallus) or on separate gamophyta. The fertilization of the ovum by a sperm results in the formation of an embryo (oospore). The embryo developes, under suitable conditions, into a sporophyte (Fern), which in its turn produces spores in sporangia borne on sporophylla. Each spore produces, on germinating, a new gamophyte.

In the Moss the ovum (oosphere) is produced in an ovarium (archegonium), and fertilized by a sperm (antherozoid), formed in a spermarium (antheridium). The embryo, which is parasitically attached to the gamophyte (Moss, oophyte) becomes a sporophyte (sporogonium, seta + theca). The sporophyte developes spores from a sporogenous layer (archesporium), which again develope into Moss plants, or gamophyta. The interesting transition stage, or "protonema," may represent the rudiment of a

lost true sporophyte, from which a secondary sporophyte has arisen by budding.

In Selaginella the ovum (oosphere) is developed in a rudimentary ovarium (archegonium) sunk in the tissue of a gamophyte (prothallus, macrospore) still enclosed within the wall of the spore. Similarly the sperm (antherozoid) is produced from a rudimentary spermarium (reproductive cells of the microspore), which, in turn, is connected with a rudimentary gamophyte (vegetative cells of microspore). The product of fertilization is an embryo, which in time developes into a sporophyte (Selaginella plant), capable of producing two kinds of spores—gynospores (macrospores) and androspores (microspores) in gynosporangia (macrosporangia) and androsporangia (microsporangia). [In passing, it may be noted that the term "macrospore" is etymologically wrong, for μακρος means "long," not "large"—megaspore would be more nearly accurate.] These two kinds of spores are able to form, whilst still enclosed by their spore-walls, the rudimentary gamophyta above referred to.

Again, in the case of the Spermaphyta, the several stages are equally well represented, and the same terms will be found applicable. The ovum (oosphere) is here not enclosed in an ovarium at all, but lies beneath the two so-called "synergidae," the sole remnant of the ovarium.* The sperm is not differentiated, the entire contents of the spermarium (pollen tube) acting as the fertilizing agent. The vegetative cells of the pollen grain represent the lost male gamophyte again, as in Selaginella, enclosed within the spore-wall. The fertilized ovum becomes an embryo capable of forming a plant, or sporophyte, which produces on the edges of certain leaves

* "On the Embryosac and Development of *Gymnadenia conopsea*." H. Marshall Ward. Q. J. M. S., vol. xx.

gynosporangia (ovules) and androsporangia (anther lobes). The gynosporangium forms one gynospore (embryosac); the androsporangium produces many androspores (young pollen grains), which produce respectively female and male gamophytes, forming ovaria and spermaria respectively.

In such a form as *Fucus* we find the ovum (oosphere) produced in a simple stalked ovarium (oogonium), fertilized by a sperm (spermatozoid), produced in a spermarium (antheridium), the result being an embryo (oospore). The embryo, however, does not produce a sporophyte, but a gamophyte, which recommences the cycle. The absence of the asexual generation is to be accounted for by the large number of ova and sperms, the certainty of their conjugation, and the nature of the medium (sea water) in which the Fucaceæ live rendering special precautions (in the shape of spores) for the maintenance of tribal life unnecessary.

Contrasting this with the life-history of the Fungi, we observe that the restricted nature of the food supply necessitates special provision for the maintenance of tribal life necessary. Many spores are lost, but the number formed is enormous. Had the fungus to depend on embryos (sexually-produced plants) for multiplication, not only would much more time and energy be required for their formation, but fewer would be formed, and the chances of all the embryos reaching a suitable soil or medium would be immensely fewer.

The Zygomycetes possess neither ova nor sperms. The ovarium (club-shaped hypha) itself fuses with the spermarium (antheridial branch), forming an embryo (zygospore). The embryo in germinating forms a sporophyte (mycelium) which carries sporangia (gonidiophores) bearing spores (gonidia). That the sporangium is sometimes only a stalk with spores freely exposed is merely a

useful variation of the usual sac-like form. These spores are able to form another generation of sporophyta, and their spores in turn yet another until the conditions of the environment are such as to necessitate the recurrence to the gamophyte stage.

How will this terminology apply lastly in the higher Fungi, such as the Ascomycetes and Basidiomycetes?

In the case of the Ascomycetes, the embryo (fertilized ascogone) becomes an intermediate formation (sporocarp, sclerotium, &c.) which forms what are known as ascospores. Each of these ascospores is capable of forming a sporophyte (mycelium), which produces spores (gonidia) on sporangial stalks (gonidiophores). The reduplication of the embryo is only another example of the many methods found among Fungi of increasing the chances of their remaining permanently on the face of the earth, comparable to the phenomenon known as embryonic blastogenesis among animals. Naturally the formation of these delayed products of sexual union involves the development of an intermediate structure, the so-called sclerotium or fructification.

Lastly, among the Basidiomycetes the sexual generation is entirely wanting, the sporophyte being able to produce spores in such numbers that all chance of possible extinction is done away with, while the plant probably obtains something corresponding to a sexual stimulus from the medium on which it lives, as suggested by Marshall Ward.*

The following table explains itself. The life histories of a few representative groups of vegetals are represented with the names in ordinary use for their reproductive organs and stages affixed, whilst at the top of table is given the life history of a typical form, with the corresponding terms employed, as suggested above.

* "Sexuality of Fungi." Q. J. M. S., 1884.

PLANT.	GAMOPHYTE.	OVARIUM.	OVUM.	SPERMARIUM.	SPERM.	EMBRYO.	Products of Embryonic BLASTOGENESIS.	SPOROPHYTE.	SPORANGIUM.	SPORE.	Gam.	Spor.
VAUCHERIA	Vaucheria	oogonium	oosphere	antheridium	antherozoid	oospore		Vaucheria	vegetative-cell	swarm-spore	G	S
EUDORINA	Eudorina	cell of cœnobium	large daughter cell	cell of cœnobium	small daughter cell	zygospore					G	
ULOTHRIX	Ulothrix	vegetative-cell	zoospore	vegetative-cell	zoospore	zygospore	swarm-cells	Ulothrix	vegetative-cell	zoogonidium	G	S
ŒDOGONIUM	Oedogonium	vegetative-cell	oosphere	vegetative-cell	antherozoid	oospore	swarm-cells	Oedogonium	vegetative-cell	zoogonidium	G	S
SPIROGYRA	Spirogyra	vegetative-cell	contents of vegetative-cell	vegetative-cell	contents of vegetative-cell	zygospore					G	
CHARA	Chara	archegonium	oosphere	antheridium	antherozoid	oospore					G	
ECTOCARPUS	Ectocarpus	sporangium	female gamete	sporangium	male gamete	zygospore					G	
LAMINARIA								Laminaria	zoosporangium	swarm-spore		S
CUTLERIA	Cutleria	female sporangium	female swarm-cell	male sporangium	male swarm-cell	oospore		[pro-embryo]	[zoosporangium]	[swarm-spore]	G	S
FUCUS	Fucus	oogonium	oosphere	antheridium	antherozoid	oospore					G	
NEMALION	Nemalion	carpogone	contents of carpogone	spermogonium	spermatium	sporocarp	carpospores	Nemalion	vegetative-cells	tetragonidium	G	S
PENICILLIUM	Penicillium	ascogone	contents of ascogone	pollinodium	contents of pollinodium	fructification	ascospores	Penicillium (n)	gonidiophore	gonidium	G	S(n)
PUCCINIA	Puccinia			spermogonium	spermatium	æcidium	æcidiospores	Puccinium	[gonidiophore]	teleutospore uredospore	G	S
AGARICUS								Agaricus	[gonidiophore, pileus + stalk]	basidiospore	G	S
POLYTRICHUM	Polytrichum	archegonium	oosphere	antheridium	antherozoid	oospore		seta + theca	spore sac	spore	G =	= S
PTERIS	Prothallus	archegonium	oosphere	antheridium	antherozoid	oospore		Pteris	sporangium	spore	G	S
SELAGINELLA	contents of mature microspore contents of mature macrospore	archegonium	oosphere	sexual-cells of microspore	spermatozoid	oospore		Selaginella	macrosporangium microsporangium	young macrospore young microspore	G	S
PINUS	contents of mature pollen grain contents of mature embryosac	archegonium	oosphere	pollen tube	contents of pollen tube	oospore		Pinus	ovule anther lobe	young embryo sac young pollen grain	G =	= S
RANUNCULUS	contents of mature pollen grain contents of mature embryosac	synergidæ	oosphere	pollen tube	contents of pollen tube	oospore	[polyembryony]	Ranunculus	ovule anther lobe	young embryo sac young pollen grain	G =	= S

NOTES of a VISIT to MADEIRA and the CANARY ISLANDS.

By Isaac C. Thompson, F.L.S., F.R.M.S.

[Read 14th January, 1888.]

During the spring of the year just expired, in company with my friend Mr. W. S. McMillan, F.L.S., I visited Madeira and the Canary Islands, with the object of examining and collecting specimens of their marine fauna. We were provided with dredge, tow-nets, microscope, and all the necessary apparatus and material for preserving the specimens obtained. We took passage in the ill-fated "Senegal," a steamer belonging to the British and African Mail Steamship Company, afterwards wrecked and plundered by the natives on the African coast on the return voyage. There being no ladies on board, we were fortunate in securing the ladies' cabin, with a good table and room to work with the microscope, wind and weather permitting.

Steaming at ten miles an hour over the prolific waters, how were its minute living denizens to be captured? Our genial commander, Captain Brown, thought more of his duty to the mails than to biological science, and did not appreciate the idea of allowing the engines a few minutes' pause in mid-ocean. We constructed a long, narrow, strong canvas bag, weighted, and with a bottle secured round the neck at lower end, and threw it over; but after a short pull it was found that everything was washed out as fast as it went in, so that had to be abandoned. On the fourth day out, however, the funeral of a poor fireman necessitated a pause of a few minutes, during which we were able to throw over our "Challenger" tow-

net, and succeeded in obtaining a quantity of surface life, affording ample employment for the rest of the voyage. The haul consisted almost entirely of Copepoda: *Calanus finmarchicus*, *Centropages typicus* and *C. brachiatus*, *Dias longiremis*, and some other species, nearly all found on our British coasts. These, like all subsequent tow-nettings, were at once transferred to a preservative solution of glycerine, alcohol and water, from which they could at any time be mounted in glycerine jelly or Farrant's medium. By this treatment the varied colours of small crustacea remain for the most part intact for an indefinite period.

On the early morning of the eighth day out, we passed the wild headlands of Porto Santo; and soon after, the precipitous barren heights of the Desertas came in sight on our left, the mountains of Madeira rising above the clouds that obscured the horizon on our right. On the afternoon before sighting land, we passed near two good-sized whales, and amongst the several birds that were noticed was the beautiful crested hoopoo, which flew about the vessel for a short time when we were not less than 150 miles from any land.

Rounding the rocky coast of Madeira, we anchored in Funchal Bay, and spent most of our few hours' stay tow-netting in the deep clear waters. Multitudes of the beautiful *Physalia* (Portuguese men-of-war), glittering with iridescent colours in the sunshine, were elegantly floating about the surface, and occasionally their long purple tentacles would get entangled or attached to the rope, when as we pulled up the net we were painfully made aware of the presence of innumerable microscopic lasso threads loosened from their tiny coils by the slightest touch. We found the *Physalia* plentiful wherever we went further south, and brought home some dried specimens measuring not less than eight inches in length.

In some places the high-water line was strewn with multitudes of them.

Funchal has no proper landing place, and as there is often a heavy surf beating over the precipitous beach, it is somewhat of a feat to reach terra firma. As the boat nears the shore the rowers wait for a good wave, which, with a spurt on their part, lands the boat high and dry on the beach. It was near the middle of April, and the heat was very intense. Vegetation was everywhere most luxurious, the gardens being masses of exquisite flowers and shrubs. Amaryllis, Banana, Bougainvillæa, Cactus, Camelia, Clematis, Eucalyptus, Fig, Geranium, Heliotrope, Hibiscus, Lupin, Magnolia, Maple, Orange, Palm, Petunia, Tree-fern, Wisteria, and many others, we noticed very abundant.

Returning to the "Senegal," after a too hasty walk of a few hours about the environs of Funchal, haunted by a troupe of beggars and importunate guides, we again brought the tow-net into requisition with good results in the Bay, and soon after sundown left Madeira for Teneriffe.

At ordinary speed it is about a twenty-four hours' voyage, but as it would be useless to arrive before day-break, we "slowed" all the way, and were able to admire the beauty of the "life on the ocean wave," both in the colours of the innumerable *Physalia*, here seen in thousands, and the elegance of the flying-fish skimming near the surface, of which we observed a considerable number. About noon we passed at a distance the bleak, rugged Salvages Islands, uninhabited by man, there being no fresh water anywhere about them; and rabbits and wild fowl are said to hold undisputed sway. Going up on deck in the early morning, we were greeted with one of those sights which for ever leave their impress on the memory. A summer haze covered the dark volcanic buttresses of

Teneriffe, and high up in the heavens rose the majestic snow-covered Peak 12,180 feet, with the sunlight glistening upon its pointed crest.

Santa Cruz, the capital of the island, is a picturesque little town, with bright many-coloured houses, and memorable as the scene of Nelson's capitulation. His flags are carefully preserved in the Church of the Conception, and are shown with pride to the passing visitor. We townetted in the harbour during our few hours' stay, and obtained a large variety of Copepoda. It was a gorgeous morning, but scorching hot, as we left Teneriffe for Grand Canary, about sixty miles distant, but plainly visible in the clear atmosphere. The Peak is much more imposing when seen from a distance than from near its base, and as we neared Grand Canary its majestic appearance was very striking, and again and again excited our admiration whilst staying there.

The lofty, precipitous, rocky cliffs of Grand Canary, especially on its north-west side, are very grand as viewed from the sea; but on rounding a dark volcanic promontary called the Isleta, a long stretch of flat sandy shore is before us, with the town of Las Palmas at the water's edge some three miles distant. There are several fine buildings, including the cathedral, museum, market, and a few open spaces planted with trees and fragrant flowers. Here the native green canary is conspicuous by its happy song; and here the Canary belles sometimes promenade, but always chaperoned by the prudent mamma or aunt. Canary courting is indeed a somewhat tame business, and has to be conducted in public; so as you walk the streets at intervals may be seen a sentimental Romeo straining his neck upwards, and whispering sweet loud breathings to Juliet, who is stationed at the upper window, looking sweetly down at her adorable.

Parrots, canaries and love-birds are in open cages outside many of the houses, and with a ring attached to the foot by a thin cord enjoy a good measure of freedom. Even here the canaries turn yellow by confinement.

Las Palmas has a remarkably Moorish appearance, with its irregular flat-roofed houses and high palm trees; and a few camels near the landing place help the resemblance. Never was there a more atrociously planned town. A long street, the main thoroughfare, composed of poor houses with their backs close to the sea, obstructs any view or promenade; but as the upper part is on a steep declivity, fine views are obtained from the roofs, which are all accessible from the houses, and all being white, the glare is very trying. A secluded spot on the roof of our hotel made an excellent drying ground, and there our daily captures of Echinoderms, Physalia, &c. were spread out to bake in the sunshine.

We paid several visits to Confital Bay, at the other side of the Isleta, wading about amongst the rocky pools, and found it a capital hunting ground. Physalia, with their long spreading tentacles, were left high and dry all about, but with bare feet had to be carefully avoided. We found five species of Nudibranchs, some of them very large, several Ascidians, a few species star-fish and sea urchins, actinia, &c. We were not so fortunate as to find the *Stellaria webbiana* or *Asteria canariense*, two large species of star-fish sometimes found in this locality, measuring about a foot from the ray tips across. The little cowrie shell was very abundant in all the pools, as was also the beautiful iridescent *Haliotis tuberculata*, and many spiral shells. Strewed along the sandy shore were thousands of the elegant little white *Spirula peronii*, and rarer was the very fragile blue ocean snail *Ianthina fragilis*, which secretes a float of numerous air bladders.

Cuttle-fish are very abundant in the rock pools at low water, and in one deep pool we found a good-sized Octopus coiled up in some loose rock crevices, which it adhered to by its suckers with so tenacious a grip that it was with great difficulty we were able to dislodge the animal and effect a capture.

The indigenous land mammals and reptiles are not numerous. The large breed of dogs, from which the Canaries are supposed to have derived their name, is long ago extinct, though their remains have been found. Lizards are very abundant, but all are included in three species. We found mosquitoes very troublesome, and were victimized by them in spite of mosquito curtains with which most of the beds are furnished. Large black flying-cockroaches too are common, even about the bedrooms in Grand Canary, and although we found them on two successive nights, our male chambermaid said that each was the first he had ever seen, and evidently hinted as politely as possible that we had imported them.

There is much to be seen in Grand Canary, but it is like the Lotus country,

> "In which it seemed always afternoon.
> All round the coast the languid air did swoon,
> Breathing like one that hath a weary dream,"

and there is not much inclination for any exertion. We found sea dredging attended with difficulties. There is usually a considerable surf and swell on, and we had to take eight Spanish sailors to manage the boat. The rocky bottom is very deep, except very near the shore, and with thirty fathoms of rope to the dredge we felt it scraping the surface of hard rock, frequently catching in crevices or jutting edges, and seldom fetching up much except a few Echinoderms, broken bits of coral, &c. The steepness of the coast appears to prevent the growth of much Algæ,

and may thus possibly account for a paucity of marine life near to the land. Once the dredge brought up an Echinus, with very long black spines, at which the sailors all looked aghast and entreated us not to touch it as the long moving spines were considered very venomous. The spines were about eight inches in length when fresh, but contracted very much in drying. Coral is found round the Islands, but not at the accessible parts where we dredged, though our boatmen always vaguely said that "to-morrow" they could take us to places where we could get any quantity. But the Spanish to-morrow is a symbol of procrastination not to be seriously taken in a literal sense, and to-morrow's corals were never found. The tow-net at Grand Canary from whatever cause yielded much smaller results than at Madeira and Teneriffe, nor did we find any surface organisms peculiar to the locality not found in the other islands.

Taking a sun-protected carriage, we made a long day's excursion into the interior of Grand Canary, to visit the famous crater the Caldera, and the very interesting cave dwellings of Atalaya, inhabited by the descendants of the ancient Guanches. A winding well-made road led us to a considerable ascent, commanding extensive views, with Teneriffe and its superb Peak on one side, and on the other a distant view of the Island of Fuerteventura and its two rounded heights, this island being only about sixty miles from the African coast.

Banana orchards and orange groves we passed in plenty, and fig trees grew at the road sides everywhere. Prickly Pears, Aloes, and Cacti are used in place of hedges, as a border to the roads, answering the purpose admirably. When steaming across to Grand Canary, at many miles distance, we were struck with what looked like long rows of white tents at various places. They proved to be large

plantations of prickly pear, for the growth of cochineal, still an important industry, though greatly lessened since the discovery of aniline dyes. The cochineal insects with their larvæ are protected upon the fleshy fronds of the prickly pear by white canvas coverings, which are fixed to the plant by means of fish bones, until the insects are ready for gathering.

Leaving the carriage at the foot, a steep climb took us to the verge of the Caldera crater, one of the most perfect volcanic craters in existence. It is just a mile across, almost a circle, and with a nearly level rim all round the upper part, being 1450 feet above the sea. It looks like a huge well, the sides being very perpendicular of black volcanic rock. At the foot, 700 feet deep, is a large green plateau, with a solitary farm-house surrounded by orange trees, and said to be a very healthy locality. At a short distance from the Caldera, and a few hundred feet higher, are the cave dwellings of Atalaya, honeycombing the sides of a hill in terraces. We were soon surrounded by their remarkable, swarthy, half-clad inhabitants, begging and entreating us to buy specimens of their industry. What the social life of these curious people can be it is difficult to imagine. The cave opening admits the only light or ingress to their one or two chambers, and here the women and children sit about on the ground, making pottery ware of a plain description, and just the same in character and process as that of their ancestors the Guanches. No other pottery is used in the country, and the women and girls may be constantly seen with their large jars at the public fountain, evidently the gossiping rendezvous of the place, or carrying them on their heads full of water; for Canary has been truly called a "rainless paradise," rain only usually occurring in about three months in the year.

In England we are not prone to grumble over the

monotony of sunshine, but in Canary one positively grows weary with the continual brightness, and feels that,

> "Hateful is the dark blue sky,
> Vaulted o'er the dark blue sea:"

sometimes almost longing for the invigorating influence of a refreshing November fog. The arrangements for the conduct of water in the country are excellent, but nevertheless it often has to be carried by the women in the broiling sun for long distances, as at the Isleta, where there is no spring or supply of any sort.

The Natural History Museum in Las Palmas is well worth a visit, as it has a fine collection of objects found about the Islands, including a large number of Guanche remains, skulls, bones, &c. It is a remarkable fact that a large proportion of the skulls found have indentations on the right side and above the forehead, so deep as to be almost holes, and yet clearly showing that the wound had healed up. From these holes occurring in the same place, it would appear that the weapon with which they fought was of one kind and handled in one way. We noticed precisely the same appearance in Guanche skulls turned up during our subsequent visit to Teneriffe.

On proceeding to use our note-books at the museum we perceived an extraordinary flutter of excitement among the officials, and presently a small procession approached us, headed by Señor Dr. Don Gregorio Chil y Naranjo, who most courteously insisted on unlocking the cases, offering to aid in our examination of the specimens. The distinguished doctor seemed to be most kindly disposed towards us, and we ventured to hint how gladly a spare Guanche skull would be accepted by his foreign visitors. He at once fell in with our wish, and in triumph we carried off one that might have been the skull of an illustrious Guanche lawyer, but to us was simply a curious ana-

tomical specimen, which is now the property of the Zoological Museum of Liverpool University College.

Space will not admit of more than a mention of a visit to Telde, a little picturesque town remarkable for its many tall palm trees and a large garden open to visitors full of gorgeous shrubs and flowers.

The Canaries have been aptly likened to a rat-trap, being very easy to reach but not so easy of escape from, for the return steamers arrive with little warning, and are usually well laden with passengers from the various African ports, as experience taught us.

After a week at Grand Canary we returned to Teneriffe, in order to visit Orotava, on the north side of the island. A seven hours' coach drive led us thither from Santa Cruz, via Laguna, a cool summer resort 2000 feet above the sea. The Puerto or port of Orotava, distinct from the Villa or old town of Orotava which is two miles inland, is grandly situated almost under the shadow of the Peak. But the view of it from here is disappointing, on account of the long dark stretch of Mount Tigayga which fills up the foreground, cutting off the bottom of the Peak, and leaving only a conical hill in the centre. The ascent can be made on horse-back to within 1500 feet of the summit, the highest point being a small cluster of rocks at the edge of a crater which constantly emits hot sulphurous fumes, as though to remind the adjacent dwellers that it may yet again burst out with renewed activity. It is I believe exactly a hundred years since its last effort, and it might afford a grand centenary exhibition. The Cañadas, the bed of the old crater, is a long flat surface 7750 feet above the sea, and is covered with yellow pumice. Professor James Geikie, the advantage of whose company we had during most of our journey, thinks it probable that at some former period the Peak was very much higher than

now, and the many craters around it give some idea of its former magnitude.

On a broiling hot day we climbed up to one of the lower cinder craters, now covered with vines and other vegetation. A large species of Dodder (*Cuscuta*) grew in profusion over some leguminous shrubs, completely destroying many of them.

A little way out of the town are the Botanical Gardens, wherein we found the Dragon tree, and a fine collection of native trees, shrubs and flowers; amongst them the *Pinus canariensis, Euphorbia canariensis, E. balsamifera*, Eucalyptus, Magnolia, yellow Bignonia, Cobæa, Oleander (white, yellow and red), Amaryllis of varied hues, Hibiscus, Poinsettia, Pampas-grass, Bougainvillæa, &c. Humboldt mentions an immense dragon tree in Teneriffe, near to here, which was supposed to be between 6000 and 10,000 years old; it was from 50 to 60 feet in height, and had a circumference of 45 feet. Piazzi Smith saw it in 1856, and it was destroyed by a storm in 1867. No other specimen approaching it in size is, I believe, known to exist, though several good sized ones are still to be seen.

In a sunny part of the gardens, adjacent to a fountain, we noticed the leafy branches of some of the smaller trees, and especially of the lower palms, covered with little tree frogs of a brilliant grass green and golden yellow colour, but so exactly resembling the foliage that unless carefully looked for they might most easily be passed unobserved. They are from one inch to one and a half inches in length, and at night croak loudly. They are evidently very common. I brought several to England, and have placed a few in a hot-house; they are, however, most difficult to find, from their colour, but continue to proclaim their existence at dusk. Lizards were very common, but we saw none of the green species so common in Italy.

We spent the chief part of our stay at Orotava town-netting and shore collecting. The waters seemed much more prolific in surface life than at Grand Canary, and we collected a large amount of material, chiefly Copepoda, the results of which I have recorded, along with those of the other Islands, in a paper recently communicated to the Linnæan Society. It enumerates sixty-five species of Copepoda in all, six of which are new to science, three of them requiring new genera. Of the sixty-five species, twenty-three are known to British waters, and these mostly belong to the Harpacticidæ.

The number of species in each family are as follows:—

Calanidæ	30	species.
Cyclopidæ	4	,,
Harpacticidæ	17	,,
Corycœidæ	11	,,
Artotrogidæ	3	,,

The new species are:—

Candace brevicornis.
C. nigrocincta.
Acontiophorus angulatus.
Mecynocera clausii.
Machairopus santa-crucis.
Cymbasoma rigidum.

From a pretty thorough examination of the material collected, I am of opinion that the Copepodan fauna of the respective Islands, though they are separated by considerable distances, varies in quantity rather than specifically. For excepting several cases in which only one or two of a species were found, and which probably indicated rareness of that species, their geographical distribution appears to be general amongst the Islands.

In the deeper pools, at low water, Holothurians were common, as also *Aplysia* (sea-hare) of very large size, some measuring nearly one foot in length. Some were of a dark purple, others a light grey marked with black. When disturbed they emitted a deep purplish fluid staining everything around. One of our nets was indelibly dyed by it. Darwin, in "The Voyage of the Beagle," describes this large species, and states that it has "an acrid secretion spread over the body, which causes a sharp, stinging sensation, similar to that produced by the *Physalia*, or Portuguese man-of-war." Several which we handled freely certainly did not exhibit this power.

About the rocks, above high water mark, we noticed quantities of moderately sized, flat, black crabs, very active in movement, and in the pools an extremely fragile white crab, beautifully marked with red, and which broke almost with a touch. At high water mark all along the beach we found quantities of pumice stone.

The sunsets here were wonderfully gorgeous, and the varied hues of light over the Peak singularly beautiful; while in the distance, sixty miles off, was clearly visible the dark outlines of the Island of Palma. The twilight is very short, and at midsummer it is dark about six p.m., when the frogs at once commence their innings and keep it up vigorously. On one occasion we tow-netted after dark, about a mile out, and brought up a quantity of phosphorescent schizopods, some of which Mr. A. O. Walker, F.L.S., has kindly undertaken to examine and report upon.

REPORT on some CRUSTACEA from the CANARY ISLANDS, collected by Messrs. I. C. Thompson, F.L.S., and W. S. McMillan, F.L.S.

By Alfred O. Walker, F.L.S.

[Read 14th January, 1888.]

I have examined the above with the following results. The collection is very interesting, as showing how widely distributed certain forms are. Most of the specimens were preserved in Deane's solution, but two were mounted on microscope slips. Of these, one was *Gastrosaccus sanctus* (Van Beneden), and the other a larval form.

Amphipoda.

Of this order there was only a single specimen, *Tritæta dolichonyx* (Nebeski), of which the most characteristic feature is a curious excavation in the anterior margin of the first gnathopods. It has only recently been discovered in the Adriatic, and described by Nebeski, and Mr. Stebbing (to whom I am indebted for the name) has also still more recently received it from the Clyde, where it was taken by Mr. Robertson.

The genus *Tritæta* was formerly included in *Atylus*, from which it is principally distinguished by the elongated merus joint and very short carpus and propodos of the pereiopods, especially the two first. It has hitherto been represented in the British fauna only by *Tritæta (Atylus) gibbosus* (Bate). This resembles *T. dolichonyx* so closely in every respect, except the notch in the hand of the first gnathopod, that one is tempted to regard the latter as a

mere variety. In the figure of *A. gibbosus* in the "British Sessile-Eyed Crustacea" the position of the gnathopods is inverted.

Isopoda.

The only representative of this order is a single small specimen of *Eurydice pulchra* (Leach), one of the commonest crustacea throughout our own district.

Schizopoda.

Of this order I find only two species (except the larval forms mentioned above), which are:—

1. *Siriella crassipes* (Sars, Middelhavet's Mysider Arch. for Math. and Naturvidensk, Christiania, 1877).

Of this species there are a considerable number of specimens, ranging in size from 3 mm. to 7 mm. in length. This last is less than half the length of Sars's male specimens taken at Goletta, and I therefore suspect that none of them are full grown. I am confirmed in this view by the fact that the number of spines on the outer margin of the outer branch of the uropods ranges from two in the smaller to ten in the larger specimens, while Sars's adult specimens had fifteen. The most obvious distinction between this and the allied *S. clausii* (Sars) is in the tip of the telson. Between the two large apical spines with which this is furnished in both species there are three very small spines. In *S. clausii* these are of equal length, while in *S. crassipes* the central spine is at least twice as long as the side spines. In my specimen these lateral spines are so small that they can only be discerned with a $\frac{1}{4}$-in. objective. *S. crassipes* has so far only been taken in the Mediterranean.

2. *Gastrosaccus sanctus* (Van Beneden, Recherches sur la Faune Littorale de Belgique, 1861—non Norman Rep. Brit. Association, 1868).

A few small specimens not exceeding 4 mm. in length, and therefore probably young, as Sars (Middelhav. Mysider, p. 65) gives 13 mm. as the length of the adult female.

In this species a portion of the hind margin of the carapace on each side of the median line is raised in the form of a tooth projecting forward. Sars (l. c. p. 72) says that the species described under the above name by Norman (l. c. supra) is a distinct species, being described as having "the fifth segment of the pleon produced backwards on the back into a well developed spine," which is not the case in Van Beneden's species. This also applies to the earlier described *Mysis spinifera* of Goes (Crust. Decapoda Podopth. Marina Suecicæ, 1863), to which Norman's species ought probably to be referred. I may add that Norman does not mention the curious tooth-like appendages above mentioned. I find that the smaller the specimen the fewer are the spines on the sides of the telson.

NOTE on the SPECIFIC NOMENCLATURE of *SALPA*.

By W. A. Herdman, D.Sc., F.L.S.,
PROFESSOR OF NATURAL HISTORY IN UNIVERSITY COLLEGE, LIVERPOOL.

[Read 11th February, 1888.]

It is well known that the life-history of *Salpa* is an example of alternation of generations. Each species has two forms, the solitary or asexual (*proles solitaria*) and the aggregated or sexual (*proles gregata*). The solitary *Salpa* has no reproductive organs, but it produces an outgrowth or stolon, which segments into a double series of young aggregated *S lpæ* united together to form a chain. After remaining in the chain condition for a time these aggregated *Salpæ* separate from one another, and each then has in its interior one or two embryos produced sexually: these embryos become solitary *Salpæ*. So, in short, the solitary *Salpa* produces asexually a chain of aggregated *Salpæ*, and each aggregated *Salpa* produces sexually a solitary *Salpa*—the two generations and the two methods of reproduction alternating regularly.

This condition of the life-history, and the fact that in some species the two forms had been found separately and described before their relationship to one another was discovered, has led to the application of two specific names to such species—not as synonyms, but the one name applicable to the solitary generation and the other to the aggregated. Thus in the case of a very common and well-known species the solitary form is named *Salpa runcinata*, Chamisso, and the aggregated form *Salpa fusiformis*, Cuvier, and it has become customary when writing of the species as a whole to use both names and both authorities, thus:—*Salpa runcinata-fusiformis*, Cham.-Cuv.

This plan of making a compound specific name was first employed by Krohn in 1846,* and it was adopted by Traustedt in his admirable revision of the species of *Salpæ* published in 1885,† and I have decided to follow it in my forthcoming Report upon the "Challenger" Tunicata, Part III.

If this plan of using the compound specific name is not generally adopted, and if it becomes necessary to denote the species of *Salpa* by a single specific name, then the difficulty of choosing one of the names will have to be faced, and the following two alternatives would then present themselves: (1) to follow the law of priority only, without reference to the sexual condition of the form first named, and (2) to choose in all cases the earliest name applied to the sexually mature or chain form of the species. This second course, which in the case of *Salpa* seems the preferable one in some respects, would however result in a form being chosen to give its name to the species which is not larger, nor more highly organised, nor longer lived than the other form, but merely because it reproduces sexually. While if either of these two alternative plans for choosing a single specific name were adopted, it would be liable to result in considerable confusion between the species as a whole and either of its constituent forms. For example, the name *Salpa fusiformis* is now generally used to indicate the aggregated form of its species, but it would if the second of the above plans were adopted come to be the name for both the solitary and the aggregated forms, and it might in some cases be difficult to tell in which sense the name was being used.

The same difficulty will have to be faced in the case of

* Ann. d. Sc. Nat. ser. 3, Zool., t. vi., p. 110.

† Bidrag til kundskab om Salperne.

many of the Hydroid Zoophytes (Hydromedusæ) when their life-histories are more accurately known and their sexual and asexual forms have been co-related. The fixed Hydroid Zoophyte in many cases gives rise asexually by budding to the free-swimming medusoid gonophore, which in turn produces reproductive elements developing into the fixed Zoophyte. This life-history is comparable with that of *Salpa*. The solitary asexual *Salpa* corresponds to the fixed Zoophyte, and the aggregated sexual *Salpa* to the free-swimming medusoid gonophore. In the case of these Hydromedusæ, as in that of the species of *Salpa*, the asexual and the sexual generations were in most cases discovered and named independently of one another, and were usually even given distinct generic names, so that the choice may have to be made not only between two specific names but also between the two genera.

If the reform in nomenclature had to be made now, and it was decided by zoologists that the two generations of the Hydromedusæ were to be known by a single generic and specific designation, I have no doubt that in most cases the name of the fixed Hydroid Zoophyte would be chosen by the majority of working zoologists; and yet that is the asexual generation, corresponding to the solitary *Salpa*. If, on the other hand, the free-swimming sexual generation were chosen to give its name to the species, the result would be an almost complete change in the nomenclature of the group. The long established, well-known names of a large number of the Zoophytes would be swept out of use, and their places would be taken by the comparatively little known names of the short-lived inconspicuous medusoid gonophores. And yet this is the corresponding course to naming the species of *Salpa* from the sexual aggregated forms.

In the case of the Hydromedusæ, the life-histories are

perhaps not yet sufficiently known to justify the general adoption of any change in specific nomenclature; but there is no such excuse for delay in regard to the *Salpæ*—the question can probably be settled as easily and conveniently now as at any future time. In the case of a few species where the solitary and aggregated forms were found at the same time and their relationship was known when they were first described—as for example, *Salpa affinis*, Chamisso—only one specific name was given, and in these cases of course there is no need for any change; but in a number of the species, where the two generations have become well known under distinct names, I believe it will lead to least confusion and trouble with synonymy in the future if the double or compound names which I have explained above be systematically adopted.

REPORT on the COPEPODA collected in MALTESE SEAS by David Bruce, M.B., during 1886-7-8.

By Isaac C. Thompson, F.L.S., F R.M.S.

With Plates VI., VII., VIII. and IX.

[Read 13th April, 1888.]

The collection which furnished the material from which this report is drawn up was summarized by Professor Herdman in Vol. I. Proceedings, of this Society. The material was obtained by means of the tow-net by Dr. Bruce, while stationed as Surgeon (a post which he still holds) at Valetta, Malta, the mass being kindly placed by him at the disposal of this Society.

In addition to the fifty-seven bottles referred to by Prof. Herdman, I have received from Dr. Bruce during the present year two bottles containing Copepoda exclusively. All the animals were transferred immediately after capture into a fluid composed of equal parts of alcohol, water, and glycerine, with one per cent of carbolic acid added.

As each bottle represents a separate gathering, and the operation of collecting extends throughout an entire year, the collection may be considered thoroughly representative of the marine surface fauna of Malta; and as might be expected the Copepoda contained therein vary considerably according to temperature and other causes; some species being found abundantly in one or more bottles and altogether absent from the rest.

The task of examining and sorting out under the microscope very many thousands of these minute crustacea has been necessarily somewhat slow and tedious, and in

this I have received valuable co-operation from my friend Mr. W. S. McMillan, F.L.S., of Maghull, who has made the Copepoda a special study.

We have made out in all sixty-eight species, belonging to the various families as follows :—

Calanidæ	41	species.
Cyclopidæ.....	3	,,
Harpacticidæ	4	,,
Corycæidæ	18	,,
Cymbasomatidæ	1	,,
Caligidæ	1	,,

Of these species, three are new to science, viz. *Acartia verrucosa*, *Zosime rubra*, and *Copilia brucii* (Pls. VI. to IX.)

Eleven out of the sixty-eight species are found in British seas, viz. :—

Calanus finmarchicus, Günner.
Pseudocalanus elongatus, Boeck.
Pleuromma abdominale, Claus.
Candace pectinata, Brady.
Dias longiremis, Lilljeborg.
Centropages typicus, Kroyer.
Isias clavipes, Boeck.
Oithona spinifrons, Boeck.
Peltidium purpureum, Phillipi.
Porcellidium viride, Phillipi.
Caligus mulleri, Leach.

It is to be noted that all the tow-netting was done at or near the surface, and it is more than probable other forms may yet be met with if sought for at greater depths, for it has recently been strikingly shown by Dr. John Murray, of Edinburgh, that at great depths in some of the Scotch lochs remarkable forms of Copepoda exist which are

hitherto unknown as occurring near the surface. Probably Dr. Bruce will find opportunity for some deep tow-netting about Malta during the present year.

DESCRIPTION OF THE SPECIES COLLECTED.

Family Calanidæ.

Calanus finmarchicus, Günner.
C. valgus, Brady.
C. propinquus, Brady.
C. pavo, Dana.
C. gracilis, Dana.

All these species of *Calanus* were found in moderate quantity, and appear to be little affected by temperature. The elegant peacock-tail plumes, figured by Dana* as terminating the caudal appendages of *C. pavo*, were not present in any of the specimens obtained, although it is evident they had become detached, a fact I noted when describing the Copepoda of the Canary Islands.†

Eucalanus attenuatus, Dana.

Very large specimens of males and females occur sparingly.

E. setiger, Brady.
E. mastigophorus, Claus.

A few specimens only were found of each species.

Hemicalanus longicornis, Claus.

A considerable number of this striking species were found.

* Dana, Crust. U.S. Expl. Exped. (1852).

† Paper on "Copepoda of Madeira and the Canary Islands," read before the Linnean Society, 17th November, 1887.

Pseudocalanus elongatus, Boeck.

This ubiquitous species seems plentiful at all seasons.

Mecynocera clausii, Thompson.

Frequently met with.

Pleuromma abdominale, Claus.

Occurs very sparingly.

Heterochæta spinifrons, Claus.

Fairly abundant.

Leucartia flavicornis, Claus.

Found in considerable abundance.

Scolecithrix dana, Lubbock.

Occurs sparingly.

Euchæta prestandreæ, Phillipi.

This is by far the most numerous of the species obtained, and forms the chief proportion of all the gatherings. Males and females occur in about equal quantities, the latter being usually provided with ovisacs.

E. barbata, Brady.

This species was found very sparingly, though from the close resemblance between *E. prestandreæ* and *E. barbata* it is probable that some of the latter may have been overlooked.

Candace pectinata, Brady.
C. pachydactyla, Dana.
C. truncata, Dana.
C. bispinosa, Claus.
C. nigrocincta, Thompson.

The three first named species of *Candace* were very common; the two latter were rare.

Dias longiremis, Lilljeborg.

Found sparingly.

Acartia laxa, Dana.

Found in considerable numbers.

A. denticornis, Brady.

Less common than *A. laxa*.

Acartia verrucosa, n. sp. (Pl. VI., figs. 1 to 9).

Length 1-20th of an inch. Cephalothorax elongated, tapering anteriorly and posteriorly; the posterior angles being produced into rounded leafy projections. Anterior antennæ (fig. 2) about the length of the body, and bearing a number of long setæ, which like those of the swimming feet are strongly verrucose throughout the middle part of their length, having the appearance of being formed of minute joints. Posterior antennæ (fig. 3) have several setæ on the outer side of the main branch, in addition to those at the apex of both branches. The first four pairs of swimming feet (fig. 6) are similar to those of *A. laxa*, but their setæ are verrucose as before mentioned. The fifth feet of the male (fig. 7) are prehensile, and are large and powerful; one side is extended into a long spinous claw, jointed near the apex and terminated by a fine seta; the other is three jointed and terminated obtusely. The fifth feet of the female (fig. 8) are each composed of one short basal joint terminated by a long spine, which is finely ciliated from near the base to the apex. The abdomen of the female (fig. 9) is two jointed, the second joint having on each side three or four long plumose setæ; the stylets in the female are two long lance-like projections without terminal setæ.

Only two specimens, a male and a female, of this very remarkable species were found, the male being

considerably mutilated. Although clearly an *Acartia*, it differs strikingly from the other known species of that genus, and may be at once distinguished by the verrucosity or roughened appearance of the setæ, and by the fifth swimming feet of both sexes, and the abdominal stylets of the female.

Ætidius armatus, Brady.

Several specimens of this easily distinguished species occur at different periods. It appears to be a species of wide geographical distribution, but has not I believe been previously recorded as occurring in the Mediterranean.

Temora dubia, Lubbock.

Common throughout the gatherings.

Centropages brachiatus, Dana.
C. typicus, Kroyer.
C. violaceus, Claus.

Of these three species. *C. violaceus* was much the most plentiful, occurring in fair abundance during all seasons. The richness of the violet colouring in the plumose setæ is very striking.

Isias clavipes, Boeck.

A few specimens only were found.

Phaëna spinifera, Claus.

A few specimens only, male and female, were found of this species; it has not I believe been recorded away from the Mediterranean, Messina being the habitat of Dr. Claus's specimens.

Lucullus acuspes, Giesbrecht.

Occurs very sparingly.

Pontellopsis villosa, Brady.

Two or three only of this rare species were found, and as was the case with the "Challenger" specimens, all were females.

Pontella strenua, Dana.
P. inermis, Brady.
P. kroyeri, Brady.
P. securifer, Brady.

Only a few of each of these species were found, but they were generally distributed throughout the seasons of the year.

P. plumata, Dana.

Found in abundance. The setæ of some specimens have a violet tinge, in that respect somewhat resembling *Centropages violaceus*.

Pontella mediterranea, Claus (Pl. VII., figs. 1 to 7).

Length 1-10th of an inch. Cephalothorax elongated, ovate six jointed; posterior angles in the male terminated by minute spine; those in the female produced into rounded leafy expansions. Rostrum broad and furcate; superior eye large, situated immediately above the rostrum; inferior eyes, two in number, conspicuously placed immediately behind the base of the rostrum. Anterior antennæ about as long as the cephalothorax, twenty-four jointed, clothed with short setæ throughout entire length; three of the central joints of the right antenna in the male are very much swollen, the first bearing a strong spine; the three following are finely denticulated, the three terminal joints being of about equal length and are of uniform width. Posterior antennæ (fig. 2) have long inner branch. Mandible (fig. 3) biting segment broad, and provided with large irregular teeth. Terminal spines of swimming feet

(fig. 4) long and narrow, with finely serrated edge. The fifth feet in the male (fig. 5) are unbranched; the right one (fig. 5 *a*) is two jointed, the second being a large and powerful claw usually doubled back upon the first and very muscular. The inner edge of the hinged claw is provided with about twenty long teeth placed longitudinally, with a rounded projection at lower end, the outer edge of the claw forming a protection to the row of teeth. The left fifth foot of male (fig. 5 *b*) is long, three jointed, muscular, and terminated by four strong curved spines. The fifth feet in the female (fig. 6) are nearly alike on each side, two branched; the outer branch having two short spines on each side and trifid at the apex; the inner branch is rudimentary, in some specimens being a single pointed spine with broad base; in others it is a rounded protuberance. The abdomen of the male is four jointed; that of the female two jointed. The caudal segments (fig. 7) are two jointed in both sexes; in the female the two terminal segments are different, that of the right side being somewhat larger than the left and rounded on the inner side; each side is terminated by five strong plumose setæ.

This species, easily distinguished by the fifth feet in the male and the caudal segments in the female, occurs plentifully in several of the tow-net gatherings from Malta. For some time I believed that the specimens represented a new species, and for confirmation, I sent specimens to both Sir John Lubbock and Dr. G. S. Brady, F.R.S., who were unable to refer it to any known species. Consequently the above description and the accompanying figures were prepared; but fortunately, while they were still in proof, I discovered that Claus's *Pontellina mediterranea* (figs. 11 and 12, Taf. xxxvi., "Die frei lebenden Copepoden der fauna Deutschlands, der Nordsee und des Mittelmeeres"), male specimens of which he found at Messina, undoubtedly

represents the same species as the Maltese specimens. There does not now seem sufficient reason for separating the species from *Pontella*, as proposed by Claus.

The variety and abundance of the genus *Pontella* found about Malta form a striking contrast to the waters about the Canary Islands, where during a series of tow-netting operations which I undertook last spring* not a single species of *Pontella* was found.

Family Cyclopidæ, Baird (in part).

Oithona spinifrons, Boeck.
O. challengerii, Brady.
O. plumifera.

A number of specimens of each species were found, but all appear to have been collected during the summer months, a fact which I have observed to be general in regard to *O. spinifrons* occurring in British waters, although very occasionally taken in winter.

Family Harpacticidæ, Claus.

Goniopsyllus rostratus, Brady.

One specimen only, a male, of this striking species was found, being taken by the tow-net at the close of last year (1887). Dr. Brady records the only other instance in which it was found, also a male, by the "Challenger" expedition in the Atlantic Ocean, near South America.

Peltidium purpureum, Phillipi.

Several specimens of this species of a brilliant red colour occur in the gatherings both of July and October of last year; the Mediterranean being its original habitat. It has

* Described in a paper read before the Linnean Society, 17th November, 1887.

been recently well described and figured by Dr. Brady,* from specimens dredged in Loch Fyne.

Porcellidium viride, Phillipi.

Found very sparingly.

Zosime rubra, n. sp. (Pl. VIII., figs. 1 to 8).

Length 1-30th of an inch. Rostrum prominent; short, thick, and pointed at apex, which bears two small hairs. Cephalothorax broadly ovate, broader towards base and apparently composed of one unsegmented carapaec. Anterior antennæ (fig. 2) six jointed, broad at base, gradually narrowing towards apex. Posterior antennæ (fig. 3) have the appearance of doubled arms, and appear to be six jointed (?). Mandible palp (fig. 4) on long stem and broadly toothed, basal portion undetermined. Maxilla not made out. First footjaw (fig. 5) short and wide, bearing several long spinous setæ. Second footjaw (fig. 6) two jointed and terminated by a long and short spine. Second, third and fourth swimming feet (fig. 7) have outer and inner branch, each three jointed, the setæ having long plumose hairs on each side and the spines bearing short hairs. Fifth feet of female rudimentary or wanting. Abdomen (fig. 8) four jointed, distinctly separated from cephalothorax, the two lower joints rather longer but narrower than the upper, and all are fringed with cilia. Caudal segments about twice as long as broad and terminated by two setæ; the outer one short and plumose; the inner very long and non-plumose. Colour, brilliant red.

One specimen only, a female, of this beautiful little species was found, and it was partially covered and obscured by a parasitical alga. Its extreme minuteness made dissection very difficult, and some parts must remain

* Appendix to Fifth Annual Report of the Fishery Board of Scotland.

doubtful. Although very different in appearance from *Zosime typica* or any described species, it has the generic characters of *Zosime*, and I have therefore placed it in that genus.

Family Corycæidæ, Dana.

Corycæus varius, Dana.
C. pellucidus, Dana.
C. limbatus, Brady.
C. venustus, Dana.
C. speciosus, Dana.
C. obtusus, Dana.

One or other species of *Corycæus* was generally present in the gatherings, but none in any abundance.

Copilia mirabilis, Dana.

This species was exceedingly abundant in a few of the gatherings, notably those of March and October, but entirely absent from nearly all. In only one specimen out of a large number examined were the caudal terminal setæ at all retained, the tendency being for them to break off at the base close to the stylets.

Copilia brucii, n. sp. (Pl. IX., figs. 1 to 7).

Length 1-4th of an inch. The first cephalothoracic segment is nearly quadrangular, narrower than the rest of the body and nearly equal to the united length of the other segments; the frontal portion is roundly indented between the eyes (fig. 1). The abdomen is five jointed, the second joint in what appears to be the male having its posterior angles on each side terminated by one strong and one slender spine with a long seta above (fig. 7); the next joint terminates partially in two short spines. The two last abdominal segments are denticulated on the ventral side only (fig. 6). The caudal stylets are long and slender,

bearing two spines and a seta on each side (fig. 7) near the termination, and one spine and seta still lower down; very short terminal setæ. Anterior antennæ (fig. 2) six jointed, about as long as first body segment, and densely clothed with long wiry setæ. Posterior antennæ (fig. 1) very large, three jointed, and terminating in a strong curved claw; the three joints each bearing a strong marginal spine, the third also having three apical spines. The three first pair of swimming feet (fig. 4) are three jointed in both external and internal branches, the inner branch of fourth pair (fig. 5) having only one joint. The three first pairs (fig. 4) are remarkably spined throughout, and have two long terminal spines with the outer branch each doubly serrated; the segments of inner border of the outer branch and those of the outer border of inner branch have their edges clothed with fine short cilia. Fifth feet are wanting.

Two specimens only of this remarkably distinct species were found both being together. It appears to differ from *C. mirabilis*, Dana, in several particulars. Its general appearance is more graceful and less angular than that of *C. mirabilis*, chiefly through the comparative smallness and frontal curving of first body segment; and both the antennæ and also the swimming feet differ very considerably, those of *C. brucii* being more highly organised; the dorsal median spines of last two thoracic segments, so conspicuous in *C. mirabilis*, are in this species entirely wanting.

I have named the species after Dr. Bruce, of Malta, to whom we are indebted for the mass of material upon which this report is drawn up.

Oncœa obtusa, Dana.

This variable species, found in abundance further south,

has not been observed north of the Mediterranean, and occurs but sparingly in the Maltese gatherings. The specimens found here have not the rich colours so characteristic of those of more southern habitats.

Saphirina ovalis, Dana.
S. inæqualis, Dana.
S. reticulata, Brady.
S. serrata, Brady.
S. opalina, Dana.
S. opaca, Lubbock.
S. splendens, Dana.
S. gemma, Dana.
S. sinuicaudata, Brady.

These species of *Saphirina*, which include most of the known forms, were generally distributed throughout the gatherings, but all very sparingly. Some retain their brilliant appearance even when mounted.

Family Cymbasomatidæ, I. C. Thompson.

Cymbasoma rigidum, I. C. Thompson.

Two specimens, both females, of this well defined species, first recorded from the Canary Islands, were found in separate gatherings.

Family Caligidæ, M. Edwards.

Caligus mülleri, Leach.

One specimen of this well known parasitic species was taken by the tow-net.

Explanation of the Plates.

Plate VI.

Fig. 1. *Acartia verrucosa*, n. sp., female, × 60 diams.
Fig. 2. Anterior antenna of do. 250 ,,
Fig. 3. Posterior antenna of do. 250 ,,
Fig. 4. Maxilla of do. 250 ,,
Fig. 5. Posterior footjaw of do. 250 ,,
Fig. 6. One of swimming feet of do. 250 ,,
Fig. 7. Fifth pair of swimming feet of male, 250 ,,
Fig. 8. Do. do. female, 250 ,,
Fig. 9. Ventral posterior of cephalothorax, showing leafy projections and fifth feet, also abdomen and caudal stylets, female, 250 ,,

Plate VII.

Fig. 1. *Pontella mediterranea*, Claus, male, × 60 diams.
Fig. 2. Posterior antenna of do. 250 ,,
Fig. 3. Mandible and palp of do. 250 ,,
Fig. 4. Terminal spine of one of swimming feet, 250 ,,
Fig. 5. Fifth pair of swimming feet of male, 250 ,,
Fig. 6. Do. do. female, 250 ,,
Fig. 7. Abdomen and caudal stylets of do. 250 ,,

Plate VIII.

Fig. 1. *Zosime rubra*, n. sp., female, × 250 diams.
Fig. 2. Anterior antenna of do. 500 ,,
Fig. 3. Posterior antenna of do. 500 ,,
Fig. 4. Biting part of Mandible of do. 500 ,,
Fig. 5. Anterior footjaw of do. 500 ,,
Fig. 6. Posterior footjaw of do. 500 ,,
Fig. 7. One of swimming feet of do. 500 ,,
Fig. 8. Abdomen of do. 500 ,,

Plate IX.

Fig. 1. *Copilia brucii*, n. sp., female, × 60 diams.
Fig. 2. Anterior antenna of do. 250 ,,
Fig. 3. Posterior footjaw of do. 250 ,,
Fig. 4. One of third pair of swimming feet of do. 250 ,,
Fig. 5. One of fourth pair of do. do. 250 ,,
Fig. 6. Spinose basal termination to lateral angles of second abdominal somite of male, 250 ,,
Fig. 7. Abdomen and caudal stylets of female, 250 ,,

CONTRIBUTIONS to the ANATOMY and HISTOLOGY of *LIMAX AGRESTIS*.

By Richard Hanitsch, Ph.D.,
DEMONSTRATOR OF ZOOLOGY IN UNIVERSITY COLLEGE, LIVERPOOL.

With Plates X., XI. and XII.

[Read 11th May, 1888.]

The material for the following research into the anatomy and histology of the Slug, *Limax agrestis*, was obtained partly at Puffin Island, when I was staying there at the Biological Station, during the end of August and the beginning of September, 1887. The animals were found in abundance after rain, creeping over the grass-covered parts of the island. The rest of the material I got in the middle of January last, and also later on, in an old quarry in the neighbourhood of Liverpool, near to the "Calderstones." Here the Slugs were easily found amongst dead leaves, beneath stones, or attached to decaying leather and other waste materials. The eggs of *Limax* in different stages of development were frequently met with even at that early period of the year.

The literature relating to *Limax agrestis* and other allied genera and species is very extensive (see pp. 165—168), and therefore it cannot be expected that this paper will bring forward many new things. My plan of working has been to collect all the information which is given in previous papers, to arrange it according to the chief systems of the body, to give an account of the results, and to fill up the remaining gaps by my own observations, or to decide as far as possible such points as were still under dispute. Naturally this paper must contain a good deal of historical

matter, but I shall endeavour to keep these parts as brief as possible, entering more minutely into such points as may seem new.

In preparing this paper I got the most valuable assistance from Professor Herdman, D.Sc., and I have great pleasure in tendering him my best thanks for his kindness shown on this and numerous other occasions.

GENERAL REMARKS.

A general account of the anatomy of *Limax flavus* s. *variegatus* has been written by Rolleston (8), and all the details, as far as they are given by that author, apply to *Limax agrestis*. This latter species differs from *Limax flavus* only in regard to Semper's organ. For whilst Rolleston (provided he is correct) figures this organ on the right side of the buccal mass, I find it in *Limax agrestis* in the form of a circle of lobules surrounding the buccal mass dorsally and laterally. Further details on that point will be given below, under the head "Nervous System." Nalepa (7), in his paper on the anatomy of the Stylommatophora, gives further information about *Limax*, while dealing, however, primarily with *Zonites*. We shall have to refer frequently to Nalepa's work, when discussing the different systems of organs.

ALIMENTARY CANAL.

The literature on the alimentary canal is scattered in different papers, Nalepa's (7) being the most complete account. Barfurth (25) and Frenzel (28) have shown that the liver consists of three kinds of cells: firstly, ferment cells (B.) or club shaped cells (F.); secondly, liver cells (B.) or granular cells (F.); thirdly, calcareous cells (B. and F.). The first two kinds of cells enclose granules of fat,

albumen and pigment, and differ chiefly in physiological respects. The third kind contains granules of calcium phosphate. The salivary glands have been described by Nalepa (7) and Bergonzini (26) as consisting of unicellular glands. These cells form groups, each of the groups enclosed by a membrane.

Descriptions of the radula in *Limax* are to be found in most text-books of Zoology, and so I shall refer only to the more recent papers of Rössler (32) on the formation of the radula, and Dybowski (27) studies on the structure of the radula in *Limax* and other Stylommatophora. In regard to the mode of its movement, however, I have to make some remarks. Cuvier (2) originally stated that in chewing the radular sac is moved first by the retractors of the mouth. This radular sac is the ventral diverticulum at the posterior end of the buccal mass, in which the termination of the radula lies imbedded. It is more or less connected with the cartilage which supports the radula. When therefore the muscles are put in action, the radula sac is first moved, then the cartilage, and thus finally the radula. The cartilage together with the radula performs a kind of peristaltic movement, and the food-particles which had been cut to pieces by the jaw (!) are seized, as if by a toothed wheel, and are carried back to the entrance of the œsophagus. Such were Cuvier's views.

Huxley's opinion differs greatly from that of Cuvier. He distinguishes two kinds of muscles : intrinsic muscles, which connect the cartilage and the subradular membrane, by their action the radula is drawn over the supporting cartilage backwards and forwards like a chain-saw ; and extrinsic muscles, which connect the cartilage with the lateral walls of the head. They move the chewing apparatus (odontophore) as a whole, and thus a licking motion is performed. Huxley, however, mentions the

investigations of Troschel (33) and of Geddes (unpublished at that time), who ascribed the chief part of the movement of the radula to the extrinsic muscles. In the year 1879 Geddes published his paper on the Mechanism of the Odontophore, and stated that in *Patella* the sliding of the radula over the cartilage is only of secondary importance; that the sliding is impossible in *Loligo* and most improbable in *Buccinum*. In fig. 1 and fig. 2, Pl. XI., I give longitudinal and transverse sections through the head of *Limax* in the region of the cartilage, and although the longitudinal section does not pass right through the median line of the head and passes only through the lateral part of the diverticulum, it is, however, distinctly seen, that the muscles which go from the cartilage to the subradular membrane are far less numerous than the muscles which connect the two lateral and the anterior and posterior surfaces of the cartilage with the body wall. Consequently I have no doubt that the chief part of the movement of the radula is due to the extrinsic muscles, although not exclusively, as stated by Cuvier. It is scarcely necessary to point out that Cuvier, although he is right in general, is wrong in regard to one point, namely the functions of radula and upper jaw respectively. At present I think nobody doubts that the upper jaw has merely the function of seizing, and the radula the function of grinding the food.

The epithelium on the roof of the mouth is provided with an extremely strong cuticle, ending anteriorly in the crescent-like jaw. In longitudinal section this jaw has the form of a tooth (fig. 1, Pl. XI.). The epithelium rests upon a layer of beautifully arranged muscle-fibres, which in the figure are shown to run in longitudinal, transverse and dorso-ventral directions, and this network of muscles would seem to enable the upper jaw to move freely in various directions.

EXCRETORY SYSTEM.

Oscar Schmidt (10) states that the kidney of the Gastropoda is a sac of which the lining epithelium is thrown into lamellar folds, and that these folds form either complete or incomplete compartments. Some years afterwards, Nalepa (7) asserted that the lamellæ of the kidney do not divide it into complete chambers, and that there are present only folds which reach nearly to the centre of the cavity. In this paper, of which I have seen only an extract, Nalepa seems to attack mainly Meckel (22), who had stated that the kidney is divided into complete compartments. According to my preparations the statement of O. Schmidt is correct. For I find in all sections (longitudinal and transverse) through the kidney of *Limax* some lamellar folds which form complete compartments, and also others which form incomplete compartments (fig. 3, Pl. X.).

The granules which are present in every one of the epithelial cells are urinary concretions. Sometimes they are the size of the nucleus, sometimes they are smaller, but occasionally also about twice the size of the nucleus; these larger ones are frequently found lying in the cavity of the kidney. These excretions have been mentioned by O. Schmidt and others. The epithelium of the kidney is not ciliated, thus differing from the epithelium in the kidney of the Lamellibranchiata and the Nudibranchiata.

Besides the papers mentioned above, there does not seem to be much literature dealing with the kidney of *Limax*. A few years ago Meuron (37) and Jourdain (36) studied the development of the kidney, and still more recently a paper has appeared by Amaudrut (35), who compares the structure and the function of the kidney and the lung in the Pulmonata.

NERVOUS SYSTEM.

The nerve collar of *Lymnæus palustris* is known to consist of two supra-œsophageal, two pedal and five visceral (parieto-splanchnic) ganglia. One pair of the latter is connected laterally and posteriorly with the pedal ganglia and join ventrally and posteriorly the three other visceral ganglia. All the ganglia are most distinctly separated from each other, and therefore *Lymnæus* is generally taken as the type for the nervous system of Pulmonata (see Lankester (5), Claus (1), Huxley (4), &c.). In *Limax* we find the same number of ganglia, but they are arranged in a different manner, the five visceral ganglia forming a row and being placed dorsally to the pedal ganglia. However the ganglia are fused together in such a manner that their number can be made out only in transverse sections. The relations between the different ganglia are easily understood by reference to fig. 1, Pl. XII., which represents a transverse section through the nerve-collar. Only the chief nerves are shown in that figure.

Beddard (38) has described a glandular structure of unknown function placed above the supra-œsophageal commissure in *Planorbis*, and two such bodies placed above the two supra-œsophageal ganglia in *Lymnæus*, and he refers to Lacaze-Duthiers (46), who had stated that this organ is present in all Pulmonata. I must say that I have not found it either in sections through the whole body of *Limax* or in the sections through the isolated nerve-collar. As I have not made any special investigations on the other parts of the central nervous system of *Limax*, I must refer to the extensive literature on this system, given at the end of this paper.

Semper's organ.—Now I pass on to discuss two organs

of rather mysterious character, which are generally mentioned in connection with the nervous system, namely Semper's organ and the pedal gland. Rolleston, in his "Forms of Animal Life," gives a dissection of *Limax flavus*, and there he figures on the right side of the buccal mass the so-called "Semper's organ." In the explanation of the plate, Rolleston says: "Semper's organ is a structure consisting of cells like those of the salivary gland, but it is devoid of a duct, and very richly supplied with nerves from the supra-œsophageal mass, and supposed by its discoverer to be, possibly, an olfactory organ." Then Rolleston refers to Semper (9), and adds: "It is large in Limaces, though small in the other air-breathing Gastropoda."

I dissected several specimens of *Limax agrestis*, to find Semper's organ, following the directions given by Rolleston, but I was not able to detect it. Thus I came to the conclusion that either Semper's organ has a different structure and position in *Limax agrestis* from what it has in *Limax flavus*, or what seemed more probable, that the description of Rolleston or Semper might be incorrect. When I looked for further information into the works of Claus (1), Gegenbaur (3), Huxley (4), Lankester (5), O. Schmidt (10), I found no further mention of the organ. But finally I met with references to it in the "Zoologische Jahresbericht," for 1880, part iii., and 1883, part iii. The one of the two papers in which Semper's organ was mentioned is written by Sarasin (49), the other by Sochaczewer (52). As I have not yet been able to get the original papers, I must be contented with the extracts given in the "Jahresbericht." The extract of Sarasin's paper is (translated into English): "The author (Sarasin) examined the region of the mouth in the Pulmonata, and found a subepithelial ganglion in the lips of the Helices. This

ganglion is continued into the 'circle of lobules' (Läppchenkranz or Semper's organ) in the form of several ganglionic nodules. A ganglion of homologous nature is also found in the Basommatophora, but they want the proper Semper's organ. In the Prosobranchiata neither the subepithelial ganglion of the lips nor Semper's organ is present." The extract of Sochaczewer's paper (52) says: "Semper's organ (or 'lobate organ beneath the mouth-edge') is not so richly supplied with nerves, as is stated by Semper, and it is more of a glandular nature."

Some time afterwards I found one specimen of *Limax maximus* (3 inches in length, when fully stretched out), and in dissecting it I detected at last Semper's organ, or the circle of lobules round the mouth-edge, as described by Sarasin. Two spirit specimens apparently of the same species which I got about the same time, were not in such perfect condition as to allow of minute dissection. Fig. 2, Pl. XII., shows a dissection of the anterior part of the body of this species. The dorsal body wall has been taken away; the tentacles, which were retracted into the body and were lying nearly parallel to the alimentary canal, have been cut through in the middle of their length, and the anterior portion of them has been bent forwards together with a small part of the skin of the head. Semper's organ is seen to consist of five lobules forming a circle and surrounding the most anterior part of the buccal mass laterally and dorsally. There are two large lobules, one on each side, and three smaller ones placed dorsally. Nerves are easily seen going to the lobules, but it is difficult to tell by dissection alone whether the nerves end in Semper's organ or simply pass through it to supply other organs. In transverse and longitudinal sections through the whole body of *Limax* I ascertained that Semper's organ consists of more or less pear-shaped cells

similar to those of the salivary gland. A duct was at first not visible. But that these glandular masses could not represent a sense-organ, as supposed by Semper, soon became evident, as the nerves which with the naked eye were seen going to them were with the microscope seen to pass through Semper's organ without giving off any branches to it and finally end in the lips round the mouth. The exact relations of these nerves and of Semper's organ, as seen in microscopical preparations, are as follows:— There is one median mass of lobules, placed posteriorly and a little dorsally to the lip, which protects the upper jaw; and there are two lateral masses of lobules, one on each side, posteriorly and a little dorsally to the two lateral lips. The nerves which pass through the lateral lobules spring from the supra-œsophageal ganglion, run along the buccal mass, and having penetrated the lobules, go to the lateral lips. Here they break up into the finest branches, and the fibres can be traced to the base of the epithelium. This epithelium covering the lateral lips, which are the same on both sides of the mouth, is formed of exceedingly high columnar cells, higher than in any other part of the body in *Limax*. Cilia are not present.

As already mentioned, the dorsal lobules of Semper's organ are smaller. The upper lip is provided with two very small nerves, which seem to spring from the buccal ganglia. The upper lip is also provided with high columnar epithelium, although the cells are here not so high as on the lateral lips. The cells of the upper lip nearer to the jaw are protected by a thin cuticle. A careful examination of longitudinal sections with a low power shows a narrow band of thin transparent tissue running from the lateral lobes of Semper's organ to a papilla placed immediately above one of the lateral lips. With a high power it is seen that this transparent tissue consisted of bundles of

very fine canals, connecting Semper's organ with the outer world. A further examination gave the following results:—The lobes of Semper's organ are masses of glandular cells of pear-shape. These cells are arranged in a bouquet-form, the pointed portion of the bouquet directed anteriorly. Also the pointed ends of the pear-shaped cells lie anteriorly, and the ends of the individual cells are continued into long canals of very small diameter, leading to a papilla placed immediately above the lips. The canals given off from the individual cells do not seem to unite, and so every cell has its own canal leading to the exterior. The walls of these canals are formed by squamous epithelium of most flattened and elongated character, with rod-like nuclei.

In regard to the function of the lips and of Semper's organ I cannot say much. I do not think that the lips have any other sense than the sense of touch; for the epithelium is of too simple a character to allow us to consider the lips as olfactory organs. Semper's organ has probably the function of keeping the lips in a moist condition, as soft tissues are certainly more able to receive slight impressions than dry and rigid ones.

The pedal gland.—Another organ of rather mysterious character is the pedal gland. Rolleston (8) describes the macroscopical appearance of this organ in the following words: "The internal circular coat of the foot is raised into two corrugated ridges along the middle line for the greater part of the length of the body by the underlying mucous gland. This gland has its bilaterally symmetrical halves arranged on either side of a single duct, which again is underlaid by a large venous sinus, very visible in the living animal along the middle line of the foot inferiorly." According to Claus (1), "the wall of the pedal gland of *Limax* and *Arion* is composed of unicellular

glands. These gland cells have very fine ducts and lead directly into the chief-duct," that is to say into the pedal gland. Nalepa (7), Simroth (51), and Sarasin (49), are also of opinion that the pedal gland is composed of unicellular glands. But Sochaczewer (52) tells us, in the same paper in which he describes Semper's organ, that in the pedal gland proper are present only glandular cells, whilst in the floor of it near the opening the so-called "Flemming's sensory cells" can be seen, placed between ciliated epithelium. He, Sochaczewer, thinks the pedal gland might be of olfactory function.

Only a few weeks ago, I got a paper on the pedal gland by Dr. Székely (Bendegúz) (53). The paper is written in the Hungarian language, but as Dr. Székely was kind enough to send me at the same time an extract of it, written in German, I am able to summarize here his chief results. The opening of the pedal gland is elliptical in transverse section; further back the lumen has a fungus-like form, and the posterior part is of a flattened lanceolate form. The floor of the duct is raised into two longitudinal folds, which in the median line are separated by a slight depression. These two longitudinal folds and the depressed portion are covered by ciliated epithelium; the other portion of the duct, especially the roof of it, is covered by non-ciliated epithelium, more or less cylindrical in form. Glandular cells are numerous, but only on the ventral and lateral portions of the duct. At the base of the ciliated cells is found a rich network of very fine fibres. Székely thinks these fibres to be connective tissue, contrary to the former investigations of Sochaczewer, who thinks them nerve-fibres. Therefore Székely comes to the conclusion that the pedal gland is no sense organ, but simply a secretory gland, furnishing the mucous necessary for creeping.

Coming now to my own investigations, I quite agree with Székely in regard to the general appearance of the pedal gland. As that author states, the floor is raised into two longitudinal folds, so that in transverse sections the lumen of the gland has a fungus-like outline. Fig. 3, Pl. XII., represents a section in which this condition is very marked, whilst in fig. 4, Pl. XII., the resemblance to a fungus is rather difficult to make out. The anterior end of the pedal gland has, however, a different appearance. Fig. 2, Pl. X., gives a transverse section through the head, in the region anterior to the buccal cavity proper, and there we see that the foot is quite separated from the head by a transverse groove. This groove, ciliated on its ventral side, must be regarded as the beginning of the pedal gland. A few sections further back we see that the two lobes coming from the head, and bending down over the lateral parts of the foot, approach the foot still more and join it at last. The lumen of the pedal gland appears then linear in outline, while further back the floor of the pedal gland is raised into the above mentioned folds. Fig. 2, Pl. XI., shows the position and outline of this organ in the region of the buccal cavity.

Further, I agree with Székely that the fungus-like outgrowth is covered by ciliated epithelium, of which the central cells are more transparent than the lateral ones, and further I find beneath the whole length of it, especially beneath the median depression, the network of extremely fine fibres, whose nature I was able to make out only after long examination, and now I fully agree with Székely in taking them for connective-tissue fibres, contrary to Sochaczewer, who thinks them to be nerve-fibres. But the gland cells, which according to Székely and other authors are so numerous in the pedal gland, are very rarely seen in my sections, although the few gland cells which I

found were very conspicuous by their secretion, which was stained bright pink by the picro-carmine.

The chief point, however, in which I differ from Székely is, that in many sections I found elongated and pointed cells, apparently of a sensory nature, placed either on the two lateral folds of the fungus-like outgrowth, or in a few cases also on the floor of the pedal gland laterally at the bases of the folds. Such cells had been found previously by Sochaczewer; but Székely, in criticising Sochaczewer's paper, supposes that these cells were accidental products, formed by cut-off pieces of the ordinary ciliated cells. I find these elongated and pointed cells so numerous, however, that I cannot accept Székely's explanation, especially as such cells are seen in no other part of the body, where pieces of columnar cells are cut off in various directions.

My opinion, that these cells are sensory cells, is strengthened by the fact that I have found numerous ganglion cells placed either below the epithelium on the lateral sides of the pedal gland, or below the longitudinal folds in the region of the elongated pointed cells. But I have never found ganglion cells beneath the median depression of the fold, where the "sensory cells" are wanting. I have often seen nerve-fibres going out from the ganglion cells, but I have not been able yet to trace a connection between the ganglion cells and the "sensory cells;" however, such a connection in all probability exists. The ganglion cells are enclosed by capsules of connective tissue, and the fibres of the connective tissue present very often an appearance of nerve fibres going from the ganglion cells to the epithelial cells, and these are probably the fibres which Sochaczewer took to be nerve fibres.

I am unable at present to give more information in regard to this enigmatical organ, the pedal gland; but I

intend to study it still further with fresh material, and I hope to be able, in a future paper, to give a further account of the structure of the pedal gland, and also the results of some experiments on its function.

I append a list of works relating to *Limax* and allied Pulmonata, which I have compiled while preparing this paper, as it may be useful to others working at the subject.

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Explanation of the Plates.

[The figures have been drawn under Zeiss *A*, *D* and *F*. As several of them have been reduced in size, I give only the number of diameters.]

b. buccal mass.
b.c. buccal cavity.
b.g. buccal ganglion.
c. cartilage, supporting the radula.
cr. crop.
cu. cuticle.
d. ducts of Semper's organ.
dv. diverticulum of buccal cavity.
f. foot.
g.c. ganglion cells.
gl. gland cells.
j. upper jaw.
l. lacunae.
l.l. lateral lip.
m. mantle.
m.c. mesoderm cells.
m.g. mucous gland.
mm. muscles.
n. nerves.
n.c. nerve collar.
n.t. nerve going to upper tentacle (optic nerve).
n.t'. nerve going to lower tentacle.
o. mouth.
oe. oesophagus.
p. pedal gland.
p.g. pedal ganglion.
p.n. pedal nerves.
r. radula.
s. salivary gland.
s.c. supra-oesophageal commissure.
s.d. duct of salivary gland.
s.g. supra-oesophageal ganglion.
s.o. Semper's organ.
s.z. sensory cells.
t. upper tentacle.
t'. lower tentacle.
v.g. visceral ganglia.
v.n. visceral nerve.

Plate X.

Fig. 1. Longitudinal section through ventral portion of head, passing through the right lateral lip. Showing Semper's organ (× 250).

Fig. 2. Transverse section through the head, anterior to the buccal cavity proper (× 40).

Fig. 3. Transverse section through the kidney (× 100). (The right side of this figure is the dorsal surface.)

Plate XI.

Fig. 1. Longitudinal section through the head, nearly in median line (× 40).

Fig. 2. Transverse section through the head in the region of the cartilage (× 40).

Plate XII.

Fig. 1. Transverse section through the nerve collar (× 55).

Fig. 2. Dissection of *Limax maximus*, to show Semper's organ.

Fig. 3. Transverse section through the pedal gland. Showing only ordinary ciliated cells on the floor of the gland (× 250).

Fig. 4. Transverse section through the pedal gland. Showing sensory cells (× 250).

REPORT on the CRUSTACEA of LIVERPOOL BAY, 1886—1887.

By Alfred O. Walker, J.P., F.L.S.

With Plate XIII.

[See "Report on Fauna of Liverpool Bay," pp. 212 to 221.]

The species enumerated in the following list were taken by dredging in the following localities :—

I. In the Turbot Hole, about 17 fathoms deep, close to Puffin Island, from the "Hyæna," on 12th June, 1886.

II. At two points between Liverpool and the Isle of Man, 20 and 30 fathoms deep respectively, from the "Weathercock," on 28th August, 1886.

III. At a point between Liverpool and Puffin Island, off the west coast of the Constable Bank, from the "Gamecock," on the 3rd September, 1887. This was the British Association dredging excursion.

The species taken on these occasions are indicated by the above numbers affixed to them.

In addition to these, dredging was carried on occasionally in shallow water (3 to 5 fathoms) in Colwyn Bay ; on one occasion with considerable success (24th May, 1887), using a small dredge having the lips masked with pieces of wood, so as to prevent it from digging up the sand, and the net lined with canvas.

Some species were also taken on the shore at low water of spring tides at Colwyn Bay.

Species not previously recorded are marked (*).

Amphipoda.

**Orchestia gammarellus*, Pallas, = *O. littorea*, Leach. In immense numbers under stones on grass above high

water mark, in company with Coleoptera (*Bembidium*, &c.), near Tal-y-Cafn, on the Conway. A female was taken at low-water mark, Penmaen, Colwyn Bay, 13th April, 1888, having probably gone to sea to deposit her ova.

**Hyale Nilsoni*, Rathke, = *Allorchestes Nilssonii*, Bate. One specimen in a large gathering of *G. locusta* from Hilbre Island, made by Mr. I. C. Thompson, on 15th November, 1886.

**Lysianassa longicornis*, Lucas. Two females (I). Taken in the same locality last year, and wrongly referred to *L. costæ* (see Report I., p. 212).

**Tryphosa ciliata*, Sars ("Oversigt af Norges Crust.," p. 81, pl. iii., fig. 4). Two specimens were obtained by placing a quantity of fragments of shells brought up by the dredge in a glass jar filled with sea water, when they swam out. The colour, which is milk white, is very protective among broken shells. Sars says that this species may be distinguished from *T. nana*, Kr., by its more compact form, by the strongly projecting lateral lobes of the head, and by having the fourth segment of the pleon depressed (Pl. XIII., figs. 1—4).

**Harpinia plumosa*, Kröyer, = *Phoxus plumosus*. Three specimens (II and III).

**Pontocrates Norwegicus*, Boeck, = *Kroyera arenaria*, Bate. One specimen in a tidal pool at Penmaenrhos, Colwyn Bay. Flagellum of lower antennæ in this case longer than the animal. Colour hyaline. Eyes bright red under a network of pure white.

**Urothoe elegans*, Bate. A specimen taken by Mr. I. C. Thompson in the tow-net off Puffin Island, at night, October, 1887. The pink colour was well preserved in Dean's solution.

Pleustes bicuspis, Kröyer, and *Calliopius bidentotus*,

Norman. It appears to me that these are one species, agreeing as far as I can see in all respects both with Boeck's description and Kröyer's figure and description of *Amphithoe bicuspis* in his "Grönlands Amphipoder." On the other hand there can be little doubt that Mr. Spence Bate has erred in referring his *Pherusa bicuspis* to that species. The form of the wrist (carpus) and hand (propodos) of both gnathopods, as shown and described both in the British Museum Catalogue and the "British Sessile Eyed Crustacea," is alone sufficient to show that the species in question cannot belong to the genus *Pherusa*, as limited by this author. In *Pherusa* the wrist of the gnathopods is narrow and as long as the hand, while in *P. bicuspis* it is short and produced backward, as shown in the figure.† Moreover Canon A. M. Norman informs me that the name of *C. bidentatus* was originally given in MS. by Mr. Spence Bate himself, who must therefore have recognized it as distinct from his *Pherusa bicuspis*. Whether it should be referred to *Pleustes* or *Calliopius* is a more difficult question. It is one of the commonest species in Liverpool Bay, and is found at all depths down to 30 fathoms, becoming more abundant as the depth increases. It varies much in colour, being pure white, freckled with red, or olive green. The long upper antennæ are generally barred with red. (I, II and III).

Pleustes bicuspis, Kröyer, "Grönlands Amphipoder," Danske Vid.-Selsk. Afhandlung viii., 1838.

Paramphithoe bicuspis, Bruzelius, Skand. Amphip. Gamm., 1859, p. 73.

Paramphithoe bicuspis, A. Boeck, Crust. Amph. Bor. und Arct., 1870.

† I have examined the type specimens in the British Museum and find that they agree with the figure in the Brit. Sess. Eyed Crust., but not with Kröyer's and Boeck's figure and descriptions of *Amphithoe bicuspis*.

Amphithopsis bicuspis, A. Boeck, Forhandl. ved de Skand. Naturf., 8 de Möde, 1860.

Calliopius bidentatus, Norman, Nat. Hist. Trans. Northumberland and Durham, 1867 [not described]. McIntosh, Ann. and Mag. Nat. Hist., 4th ser., vol. xiv., p. 268.

Non Pherusa bicuspis, Sp. Bate, Cat. Amph. Crust., Brit. Mus., 1862; and Sp. Bate and Westwood, Brit. Sess. Eyed Crust., 1863.

Head furnished with a very small beak. Body elongate; epimera much smaller than in *Pleustes pulchellus*, Kr.; back rounded. First and second segments of the pleon having each a spine in the middle of the hinder margin. Lower hind angle of the third segment of the pleon curved upwards and acute. Antennæ long. The hands of the first and second feet (gnathopods) large and oval, and armed along the edge with slender spines. The last pair of uropods having the inner branch more than twice as long as the peduncle. Telson elongate, oval. Length 6.5 mm.—Boeck, Skand. og Arkt. Amphipod., 1876, p. 308. The upper antennæ have the first joint of the peduncle as long as and much thicker than the two following. The flagellum is long and slender, and generally has the joints alternately red and white in lengths of five to nine joints. The first joint is as long as the three following. The peduncle of the lower antennæ is much longer than that of the upper, the first two joints together being about equal in length to the third, which is equal in length to but thicker than the fourth. The first and second gnathopods are almost exactly alike. In addition to the long spines (about five in number) with which the palms are armed, there are also some shorter spines and hairs; all these appear to be arranged along the two edges of the groove in which the finger folds. The last pereiopods

have the lower hinder angle of the merus joint prolonged downwards nearly half the length of the carpus. The spine on the first segment of the pleon is much shorter than that on the second, and is sometimes almost obsolete (Pl. XIII., figs. 5—9).

Dexamine spinosa, Mont. A very large specimen, approaching in size examples from the Arctic Sea, was taken in a tidal pool at Rhos Bay, 18th June, 1886.

Atylus Schwammerdamii, M. Edwards. A specimen taken at (I) differed from the common shallow water form in being larger, freckled with brown, and having brilliantly white eyes.

Halirages (Atylus) bispinosus, Bate. A few imperfect specimens in a gathering dredged by Mr. R. D. Darbishire, off Fleetwood, in 7 fathoms, October, 1886. The bulk of the gathering consisted of *Gammarus locusta* and *Atylus Schwammerdamii*.

Calliope leviuscula, Kr. Specimens collected by Mr. I. C. Thompson at Penmaenmawr are darker in colour than those from Colwyn Bay.

Pherusa fucicola, Bate. I have some doubt whether the species recorded under this name in the first Report be not the young of *C. leviuscula*.

Gammarus marinus, Leach. A few female specimens at low water, Penmaenrhos, 23rd April.

**Mœra longimana*, Leach. One female (I).

**Cheirocratus Sundevalli* = *Lilljeborgia Shetlandica*, Bate. (I). Colour, when alive, white mottled with bright red, the spots densest on the top of the head. There is a double tooth at the lower distal angle of the second joint of the peduncle of the lower antennæ. Another, male specimen, taken in the "muzzled" dredge in 3 fathoms, Colwyn Bay, 24th May, 1887.

Amathilla Sabini, Leach. Two specimens of the large

form of this species (the largest about one inch long), taken on the shore, Colwyn Bay, April and May, 1887. The young differ materially from the adult form in wanting the dorsal carina, and in the form of the last uropods. Mr. Stebbing considers *Grayia imbricata*, Bate and Westwood, to be this young form.

Stenothoe (Montagua) marina, Bate. One specimen from Fleetwood, 7 fathoms (R.D.D.).

Metopa Alderi, Bate. Penmaenrhos, April, 1887. Penmaenmawr (I.C.T.).

**Ampelisca equicornis*, Bruzelius. Several specimens at (II). This species is nearly allied to *A. tenuicornis*, Lillje, of which, as Sars† has pointed out, *Tetrommatus typicus*, Sp. Bate, and *A. Gaimardi*, Sp. Bate, are the male. The female may be distinguished by the length of the upper antennæ, which are much longer than the peduncle of the lower, and both sexes by the absence of the tufts of hairs on the under side of the peduncle of the upper antennæ, and the upper side of that of the lower antennæ. Boeck says that the back is not carinate in this species; but in a large female specimen among the above a slight carina in the pleon can be seen. The length of this specimen is about 14 mm. Boeck gives 5 mm. as the length of a female with ova.

**Ampelisca lævigata*, Lillje, = *A. Belliana*, Bate and Westwood. One specimen at (II). Several in the "muzzled" dredge, Colwyn Bay, 3 fathoms, 24th May, 1887. It has the habit of floating on the surface of the water.

**Haploops tubicola*, Lillje. One specimen at (II), found in sand taken home for examination (for shells) by Mr. F. Archer.

Photis (Eiscladus) longicaudatus, Bate (?). One female

† "Oversigt af Norges Crustaceer."

with ova at (I), May, 1885. Boeck refers this to *P. Reinhardi*, Kröyer, while Mr. Norman considers it to be identical with *P. Lütkeni*, Boeck. Neither species has the last uropoda as long as shown in the Brit. Sess. Eyed Crustacea. This species was recorded in error from Colwyn Bay in the first Report. Mons. Chevreux (Assn. pour l'av. des Sci., Blois, p. 314) also notices the length of the last uropods in Bate and Westwood's figure as being much greater than in the specimens taken by him on the coast of Brittany, and suggests that *Eiscladus brevicaudatus*, Norman (Report on Deep Sea Dredgings on the Coasts of Northumberland and Durham, 1864), might be the species he has taken. Mr. Norman informs me that a specimen was so named by Mr. Spence Bate, but no description was ever published.

**Photis tenuicornis*, Sars, "Oversigt af Norges Crustaceer," Christiania Videnskab. Forhandl., 1882. One specimen (a male) of this species, not hitherto recorded in Great Britain, taken at low water mark, among Algæ, &c., at Penmaenrhos, Colwyn Bay, 8th April, 1887. It may be distinguished from the other species by the shape of the hand of the first gnathopods, which has a concave edge, while that of the others is convex; by the lower angle of the hand being nearer to the base than to the distal extremity; and by the antennæ being less thickly clothed with hairs.

Aora gracilis, Bate. (III); Black Point, Anglesey, at low water, October, 1887.

**Gammaropsis erythrophthalmus*, Lillje. *Eurystheus erythrophthalmus*. (I and II); also at Colwyn Bay. Rather common. Colour, pale green with scarlet eyes.

Podocerus falcatus, Mont. Puffin Island; abundant at low water of spring tides, September, 1887. Boeck refers *P. pulchellus* and *P. pelagicus* to this species.

Cerapus abditus, Templeton. Black Point, Anglesey, low water. One female.

ISOPODA.

**Jæra Nordmanni*, Rothke. Under stones, Penmaenrhos, 27th June, 1887. Very variable in colour.

CUMACEA.

**Diastylis Bradyi*, Norman (Ann. and Mag. Nat. Hist., 5th series, vol. iii.). One specimen (a female), in 3 fathoms, Colwyn Bay, 24th May, 1887, in the "muzzled" dredge. In my specimen the sides, as well as the ventral surface, of the fourth, fifth and sixth segments are spinous, and the postero-lateral margin of the fifth is produced backwards about half way between the ventral and dorsal suface (i.e. on the side), and terminates in a strong spine with a smaller spine close below it (Pl. XIII., figs. 10 and 11). The only previously recorded locality for this species is Lough Swilly, Co. Donegal, where it was dredged in 15 fathoms, during the "Porcupine" expedition in 1869. Mr. Norman informs me that it has been also taken on the Northumberland and Durham coasts.

PODOPHTHALMATA.

SCHIZOPODA.

**Mysis vulgaris*, Thompson. Taken in considerable numbers by Mr. F. Archer, at the mouth of the river Alt, in brackish water. A large proportion of the specimens had the telson deformed, as described in a previous number of the Liverpool Biological Society's Proceedings.

**Mysis Lamornæ*, Couch. One specimen, in 3 fathoms, Colwyn Bay, 24th May, 1887, in the "muzzled" dredge. A pretty species, with bright red thorax, maxillæ and maxillipedes, and a red spot on the last abdominal segment before the telson.

MACROURA.

**Palæmon squilla*, Linn. One specimen (female with ova), taken in a tidal pool at Beaumaris, by Mr. H. C. Chadwick, July, 1878.

Pandalus brevirostris. (II).

Hippolyte pusiola, Kröyer. (II). Several specimens; carapace banded with red. The wrist of the second pair of legs has seven joints (and not four as described by that author), being one more than in the same limb in *H. Cranchii*, from which it is also distinguished by having a pointed rostrum. (See Kinahan, in Nat. Hist. Review, 1857, p. 159, pls. ix. and x.)

Hippolyte Cranchii, Leach. One specimen, 3 fathoms, Colwyn Bay, May, 1887.

**Crangon (Steiracrangon) Allmanni*, Kinahan. (II). Several specimens. Colour, greyish white, freckled with light red.

Crangon trispinosus, Hailstone. Colwyn Bay, April, 1887, at low water, spring tide.

Crangon fasciatus, Risso. Colwyn Bay, two specimens, dredged in 3 fathoms, 24th May, 1887.

**Palinurus vulgaris*, Latreille. A fine specimen in the Grosvenor Museum, Chester, is said to have been taken in the Isle of Man.

Homarus vulgaris, M. Edwards. A very large specimen, the hands measuring 9 inches in length; taken from under a rock in Rhos Bay, 1886.

Galathea intermedia, Lillje. (II). Rather common.

ANOMOURA.

Pagurus cuanensis, Thompson. (II). Several specimens. The shells inhabited were all covered with the sponge (*Suberites domuncula*, Schmidt), characteristic of this species.

**Pagurus lævis*, Thompson. One specimen, from Douglas 1886.

Porcellana platycheles, Penn. Abundant in spring, 1886, at Penmaenrhos. Mr. H. C. Chadwick, in lit., says, "Up to the summer of 1877 this species was well represented at extreme low water mark at Beaumaris. Since that time, however, I have not seen one." (See Report I.)

Brachyura.

Ebalia tuberosa, Penn, = *E. Pennantii*, Leach. (II). Two males.

Ebalia tumefacta, Mont., = *E. Bryerii*, Leach. (II). Several specimens.

**Portunus holsatus*, Fabr. Two specimens, dredged by Mr. H. C. Chadwick, in 10 fathoms, near Garth Ferry, Menai Straits, 1887.

Portumnus latipes, Penn. Not uncommon on the shore at Colwyn Bay, in July, 1887. It makes a complicated track on the sand, at one end of which is a small depressed mound, under which the crab is found about 3 or 4 inches below the surface. The broad last joint in the hind legs of this species seem to be used for burrowing rather than swimming. One kept for some weeks in an aquarium never attempted to swim.

Pilumnus hirtellus, Leach. One specimen, dredged off Penmon, Anglesey (Chadwick).

**Xantho rivulosa*, M. Edwards. One specimen, taken at extreme low water mark at Beaumaris, July, 1878, by Mr. Chadwick, who writes, "It was almost buried in gravelly mud. I have since searched diligently for it many times without success."

Eurynome aspera, Penn. (II). Two specimens.

Inachus Dorsettensis, Leach. (II). Two specimens.

Description of Plate XIII.

Fig. 1. Head of *Tryphosa ciliata.*
Fig. 2. First gnathopod of do.
Fig. 3. Second do. do.
Fig. 4. Third segment of pleon.
Fig, 5. *Pleustes bicuspis*, Kr.
Fig. 6. Mandible of do.
Fig. 7. Maxillipede.
Fig. 8. First gnathopod.
Fig. 9. Telson.
Fig. 10. *Diastylis Bradyi*, Norman. Head and thoracic segments.
Fig. 11. Penultimate segments of abdomen.

The COLEOPTEROUS FAUNA of the LIVERPOOL DISTRICT.

By John W. Ellis, L.R.C.P.E., F.E.S.

[Read 13th April, 1888.]

In October, 1880, the present writer commenced a series of articles upon the Coleoptera of the Liverpool district, which, after being read before the Lancashire and Cheshire Entomological Society, appeared in "The Naturalist." Previously, the only information which existed on the subject was contained in (1) two papers by Mr. C. S. Gregson, one on the Geodephaga or predaceous land-beetles, the other on the Hydradephaga or carnivorous water-beetles, of the Liverpool district (Trans. Historic Soc. of Lanc. and Ches., 1861—1862); (2) a few remarks, not amounting to more than two pages, on Coleoptera collected in the neighbourhood of Liverpool, by Mr. F. Archer (Liverpool Naturalists' Scrap Book, pp. 167 to 169); and (3) occasional notices of captures of Coleoptera in the district scattered through the pages of entomological periodical literature.

The sources of the information contained in the present, as in the preceding list, have been (1) the published records above alluded to; (2) records in the entomological diaries of Mr. F. Archer and the late Mr. Benjamin Cooke; and (3) information given me by Messrs. J. Chappell (Manchester), R. Wilding, J. H. Smedley, Willoughby Gardner, and the late F. Kinder.

During the eight years that have elapsed since the previous list was commenced many species have been added to our local beetle-fauna, a great number of new

localities have been found for species already recorded, and a few mistakes require correction.

Although the present list contains nearly thirty per cent of the British beetles* (and the writer has still a few species the diagnosis of which is undecided), very much remains to be done in the neglected families of British Coleoptera—the smaller *Staphylinidæ*, the *Trichopterygidæ* and other small Clavicorns, the *Halticidæ*, &c.

Some of Mr. Gregson's localities have disappeared; such for instance are Mosslake and Parliament Fields, by the spread of the town, and Wallasey Pool by its conversion into the Birkenhead docks; but there still remain many fine collecting grounds in the neighbourhood, such as the Wallasey and Meols sandhills on the Cheshire side of the Mersey, and those extending from Crosby to Southport on the Lancashire side, these latter differing very considerably in their flora, and therefore having a beetle-fauna somewhat different, from those on the Cheshire coast. Access to woods, and we have not many about Liverpool, is frequently difficult to obtain, on account of their strict preservation, and I doubt not that our list of timber-feeding beetles as well as of many other phytophagous Coleoptera would be largely increased by careful work in the woods about Ince Blundell, Croxteth, and Hale in Lancashire, and at Hooton and in Mid-Wirral in Cheshire. The "mosses" within the Liverpool district would well repay careful working, but their inaccessibility has hitherto prevented more than occasional visits on the part of most of the collectors of this district.

The "Liverpool district" I have defined as that portion of Lancashire and Cheshire falling within a circle having a radius of fifteen miles from the Liverpool Town Hall. This has been selected on account of its being, with a

* For tabular statement, see the concluding page.

slight restriction,* the boundary selected by the authors of the last "Flora of Liverpool."

The arrangement adopted in the following list is mainly that of the catalogue of British Coleoptera by the Rev. Canon Fowler and the Rev. A. Matthews.

COLEOPTERA.

GEODEPHAGA.

CICINDELIDÆ.

Cicindela campestris, L. Of occasional occurrence in early summer on Bidston Hill, and on other heaths and mosses. That this species hibernates is indicated by the fact that Mr. Wilding has taken it, in a torpid condition, in early spring, under stones on Thurstaston Heath.

Cicindela hybrida, L. Common on the sandhills on both sides of the Mersey. It seems to prefer the barest hills and those nearest the shore, and can there be found throughout the summer flying in the hottest sunshine. The var. *maritima*, Dej., has been erroneously recorded as occurring in our neighbourhood by Fowler (Brit. Col., vol. i., p. 4).

CARABIDÆ.

Cychrus rostratus, L. Of very occasional occurrence in widely separated localities. Mr. Gregson records it as common in woods.

Carabus auratus, L. I have a specimen of this doubtfully indigenous species which was captured in Edgehill, and given me by Mr. Gregson. This insect is probably introduced along with vegetables from the Continent, where it is abundant.

* The "Flora of Liverpool" comprises, in addition to that portion mentioned, the country within a circle of two miles' radius round Southport.

Carabus nitens, L. Formerly abundant in damp hollows in the sandhills between Crosby and Southport. A Manchester collector took about seventy specimens in one day, many years since. It still, I believe, occurs on the mosses, in May.

Carabus granulatus, L. Generally distributed, but not usually common. Mr. Smedley once took it freely, hibernating, at the foot of a wall at Bidston.

Carabus monilis, F. I have heard of no recent capture of this beautiful species in our neighbourhood, but it has been recorded from "Edge Lane, West Derby, Liscard and New Brighton," by Mr. C. S. Gregson.

[*Carabus arvensis*, F. Mr. Gregson records this species with some doubt from Prenton. I have never taken it nearer than Llangollen, and there never at a less elevation than about 1500 feet; but since it occurs on Wimbledon Common and in the New Forest, the species must not be considered invariably a mountain one.]

Carabus catenulatus, Scop. Tolerably common in elevated situations, such as Bidston Hill; less common about West Derby and Crosby.

Carabus nemoralis, Müll. Common and generally distributed.

Carabus violaceus, L. Common.

Elaphrus riparius, L, Very abundant in damp places among the Wallasey sandhills. Crosby sandhills (C.S.G.).*

Elaphrus cupreus, Dufts. Common at Wallasey and Crosby, in damp places. Recorded also from the margin of a pond between Thurstaston and Caldy, by Mr. A. H. May.

Blethisa multipunctata, L. "One specimen from Crosby

* The initials C.S.G., R.W., F.K., J.H.S., and J.W.E. refer to Messrs. Gregson, Wilding, Kinder, and Smedley, and myself, respectively.

with *E. cupreus*" (C.S.G.). Mr. Gregson informs me that he afterwards found it freely near Crosby.

Loricera pilicornis, F. Abundant at roots of trees, in moss, under stones, &c.

Notiophilus aquaticus, L. Common on the sandhills and in heathy places.

Notiophilus palustris, Dufts. Generally distributed, but less common than the preceding.

Notiophilus biguttatus, F. Abundant. Of the variety *quadripunctatus*, Dej., occasional specimens have been taken along with the type, both by Mr. Wilding and myself. Some of these have two punctures on one side and one on the other, thus bearing out Mr. Crotch's view that they are but varieties of *biguttatus*.

Notiophilus substriatus, Wat. Occurs occasionally. Mr. Chappell tells me he has taken it freely under seaweed below Leasowe Embankment, in April.

Leistus spinibarbis, F. Local. Eastham Wood (C.S.G.). Mr. Smedley and myself once took this species in abundance in the Storeton fir plantations, in March. One specimen on Flaybrick Hill (J. R. L. Dixon).

Leistus fulvibarbis, Dej. Abundant in Eastham Wood, and occasionally found elsewhere.

Leistus ferrugineus, L. Common on the Crosby sandhills, in Eastham Wood, on Aigburth shore among reeds, &c.

Leistus rufescens, F. With the preceding species at Eastham and Aigburth, &c.

Nebria brevicollis, F. One of the most abundant ground-beetles.

Nebria Gyllenhalii, Schaum. "Two near Burscough Bridge, among a heap of stones" (C.S.G.).

Dyschirius thoracicus, Rossi. Common on the Crosby shore and Wallasey sandhills.

Dyschirius impunctipennis, Daws. Abundant on the

Crosby shore, above high-water mark. Also recorded by Mr. Chappell from Wallasey. Spring.

Dyschirius nitidus, Dej. Occasionally found on the Crosby, Hightown, and Wallasey shores.

Dyschirius politus, Dej. Wallasey, but not common.

Dyschirius salinus, Schaum. Between Waterloo and Crosby, on the banks of streams on the shore (C.S.G.).

Dyschirius globosus, Herbst. Plentiful, but local, on the Wallasey sandhills in damp places; Bidston Marsh (A.H. May); Leasowe (J. Chappell); "Plentiful near Little Brighton, Crosby" (C.S.G.).

Clivina fossor, L. Common.

Clivina collaris, Herbst. Recorded by Mr. Gregson from the banks of the Alt at West Derby, and from the banks of the Birket.

Cillenus lateralis, Sam. Abundant on the clayey and muddy banks of the Alt, at Hightown. Eastham and Aigburth shores of the Mersey (C.S.G.).

Tachypus pallipes, Dufts. "Common in a damp hollow near the bridge across the Alt, Hightown. June" (C.S.G.).

Tachypus flavipes, L. Not at all a common species. I have found more specimens in my garden (Brougham Terrace) than elsewhere. I have taken it at Leasowe; and it has been recorded from the banks of the river Birket (A. H. May); Raby Mere (C. S. G.); and about clay-pits in the neighbourhood of Stanley and Westminster Roads, Kirkdale (F. K.).

Bembidium rufescens, Guér. Abundant in moss about West Derby, and occasionally elsewhere, during the winter.

Bembidium quinquestriatum, Gyll. Common in moss growing on walls around West Derby.

Bembidium obtusum, Sturm. "Banks of the Alt at Sefton" (C.S.G.); along with the preceding species at

West Derby; also on Flaybrick Hill and the banks of the Fender, Bidston Marsh.

Bembidium biguttatum, F. Common on the banks of the Alt at Hightown, and the Fender, Bidston Marsh. "Garston, near the salt works" (C.S.G.).

Bembidium æneum, Germ. Common on the banks of the Fender, Bidston Marsh; Wallasey Pool (C.S.G.), and Aigburth shore (J.W.E.).

Bembidium guttula, F. Common and generally distributed.

A variety occurs sparingly, especially on the banks of the Fender, without any trace of the red spot, and frequently without even the lighter-coloured apex of the elytra. I have seen this variety in collections under the name of *Mannerheimii*, which is, however, quite a distinct insect. I propose for this form the name of var. *obliteratum*.

Bembidium quadrimaculatum, L. Generally distributed but not common.

Bembidium quadriguttatum, F. Not nearly so common now as it used to be ten years ago; I took it in abundance in clayey ground where the Exhibition building now stands, behind Wavertree Park.

Bembidium minimum, F. Very abundant on the banks of the Alt, at Hightown, where a variety occurs differing only from the type in the presence, as in var. *normannum*, of a well marked testaceous sub-apical spot. The type form also occurs commonly on the banks of the Fender; and, according to Mr. Gregson, at Bromborough Pool.

= var. *normannum*, Dej. A specimen of this distinct variety was taken by Mr. Willoughby Gardner, at Barnston, a locality three or four miles from the shores of the Mersey or Dee.

Bembidium lampros, Herbst. Abundant everywhere, among moss and under stones.

= var. *velox*, Er. I took a specimen of this distinct form on the banks of the Fender a few years ago.

Bembidium nigricorne, Gyll. Common on the Heswall, Thurstaston, and Oxton Heaths.

Bembidium bipunctatum, L. Occasional.

Bembidium decorum, Panz. "Raby brook and river Birket" (C. S. G.).

Bembidium monticola, Sturm. "River Alt, Hightown" (C. S. G.).

Bembidium Stephensii, Crotch, = *B. affine*, Steph. I have taken a few specimens on the Aigburth shore, whence it has also been recorded by Mr. Gregson; Mr. Wilding has several specimens from West Derby; Spital, one specimen (J. H. S.).

Bembidium brunnipes, Sturm, = *B. nitidulum*, Marsh. Abundant on the Aigburth shore.

Bembidium tibiale, Dufts. "Common in brooks on the Cheshire side of the River" (C. S. G.). I have never met with either this species or *B. decorum* nearer than the Dee at Llangollen, where both are abundant.

Bembidium saxatile, Gyll. A single specimen recorded by Mr. Gregson as captured on the Aigburth shore, in 1858.

Bembidium femoratum, Sturm. Common at West Derby, on the Aigburth shore, and behind Leasowe Embankment.

Bembidium Bruxellense, Wesm. Recorded from the Aigburth shore by Mr. Gregson.

Bembidium concinnum, Steph. Abundant on the shore of the Mersey at Aigburth and Hightown.

Bembidium littorale, Ol. Very abundant everywhere.

Bembidium lunatum, Dufts. Very abundant under seaweed, &c., on the Aigburth shore, and on the banks of the Alt at Hightown. "Wallasey and Bromborough Pools. Local" (C. S. G.).

Bembidium stomoides, Dej. Recorded, on the authority of Mr. Gregson, from the river Alt, at Hightown.

Bembidium pallidipenne, Ill. Very abundant in spring on the shore at Crosby and Hightown, under rejectamenta.

Bembidium flammulatum, Ol. Mr. Smedley and myself have taken a few specimens of this species, beneath rejectamenta, on the bank of the Alt, at Hightown.

Bembidium varium, Ol. The only specimen I know to have occurred in our district was one which I found under a stone on Middle Hilbre Island, in May, 1875.

Bembidium paludosum, Panz. "A single specimen from Raby Mere, April, 1858" (C. S. G.).

Tachys parvulus, Dej. A single specimen of this species was found by Mr. J. H. Smedley in his greenhouse, and believed by him to have been introduced along with some roots of *Parnassia palustris*, which he had brought the previous day from the Wallasey sandhills.

This is the only specimen of this species known to have been captured in England; but another species (*T. quadrisignatus*) has also found a place in the British list, on the authority of a single specimen from South Shields. In his British Coleoptera, Mr. Fowler comments on the possibility of *Tachys* being introduced along with ballast; but if Mr. Smedley's suggestion as to the original locality of his specimen be correct, this explanation can scarcely account for its presence at Wallasey, for the *Parnassia* grows at least five miles from the nearest ballast.

Patrobus excavatus, Payk. Plentiful at Club Moor, West Derby (R. W.).

Pogonus littoralis, Dufts. "Under stones on the shore at Eastham and Garston" (C. S. G.).

Pogonus chalceus, Marsh. Eastham (C.S.G.); Hightown and Burton (R. W.).

Trechus discus, F. Banks of the Alt, between Hightown and Sefton (C.S.G.); fields near Stanley Road, five specimens (F.K.).

Trechus micros, Herbst. Along with *discus* (C.S.G.); three specimens near Westminster Road (F.K.); Wallasey Pool (J.H.S.).

Trechus rubens, F. Along with *discus* (C.S.G.).

Trechus minutus, F. Abundant in moss and under stones, &c.

Trechus secalis, Payk. Uncommon on the banks of the Alt, June (C.S.G.).

Pterostichus cupreus, L. Under stones at the mouth of brooks, where they join the salt water (C.S.G.); a specimen on the railway bank between Waterloo and Crosby (F.K.); "in abundance on a pathway at the bottom of the west side of Bidston Hill, running in the hot sunshine, September, 1881" (A.H. May).

Pterostichus versicolor, Sturm. Along with *cupreus*, one specimen (A.H. May). I took a pair of this species on a bank at West Derby, in September, 1883.

Pterostichus vernalis, Panz. Common and generally distributed.

Pterostichus niger, Schall. Common.

Pterostichus vulgaris, L. Abundant.

Pterostichus nigrita, Fab. Common in damp places.

Pterostichus anthracinus, Ill. Recorded by Mr. Gregson from beneath rejectamenta on the bank of the Alt, at Hightown.

Pterostichus minor, Gyll. Recorded as "common" in the district by Mr. Gregson; but though the specimens in his collection are undoubted *minor*, I have never yet met with the species.

Pterostichus strenuus, Panz. Abundant, much more so than the next species, throughout the district.

Pterostichus diligens, Sturm. Common, especially on the banks of the Alt at Hightown.

Pterostichus vitreus, Dej. Recorded from Raby Mere and Sutton, by Mr. Gregson; but I think there must be some mistake here, as the species is a truly mountain one.

Pterostichus madidus, F. Abundant.

Pterostichus striola, F. Common beneath garden refuse.

Stomis pumicatus, Panz. Common and generally distributed.

Amara fulva, De Geer. Occasionally under stones on the shore, more frequently than elsewhere at Aigburth.

Amara apricaria, Payk. Common, especially in moss during the winter.

Amara spinipes, L. A nocturnal species, frequently taken by evening sweeping. Mr. Kinder used to take it in profusion, about Kirkdale, by examining thistle flowers at night with a lantern.

Amara fusca, Dej. Mr. Wilding had the good fortune to capture a specimen of this rare species several years ago at West Derby, among *Amara apricaria*.

Amara bifrons, Gyll. Mr. Kinder found this species in abundance, in August, 1879, in (at ?) the roots of wild chamomile, near the Canada Dock Goods Station; also on the flowers at night. I have two specimens, one taken at Crosby and one at Caldy.

Amara rufocincta, Dej. Mr. Wilding has this species from Crosby, and I took a specimen last August (1887), by sweeping herbage near Lydiate.

Amara lucida, Dufts. Common on the sandhills on both sides of the river, in spring.

Amara tibialis, Payk. Common on the Wallasey and Crosby sandhills, in spring.

Amara familiaris, Dufts. Abundant.

Amara acuminata, Payk. Wallasey Pool (C. S. G.); West Derby (R. W., J. W. E.).

Amara trivialis, Gyll. Abundant.

Amara curta, Dej. "A pair taken at West Kirby" (C. S. G.).

Amara lunicollis, Schiodte. Generally distributed but not common.

Amara continua, Thoms. Among my *communis* I have for a long time had a specimen of this species, captured most probably in this neighbourhood.

Amara communis, Panz. Abundant in spring.

Amara ovata, F. Generally distributed, but not common.

Amara similata, Gyll. Generally distributed.

Amara plebeia, Gyll. Common and generally distributed.

Badister bipustulatus, F. Occurs occasionally under stones on dry hedge-banks, &c.

Sphodrus leucophthalmus, L. Mr. Gregson records the occurrence of two specimens of this rather scarce species in the neighbourhood of St. John's Market; and Mr. Smedley captured three specimens in a cellar-kitchen in Price Street, Birkenhead, some few years ago, one of which he most kindly added to my collection.

Pristonychus subcyaneus, Ill., = *P. terricola*, Herbst. Common in cellars. I have taken the species under dead animals on the Aigburth shore.

Calathus cisteloides, Ill. Abundant on the sandhills and on waste grounds.

Calathus flavipes, Fourc. Abundant on the sandhills on both sides of the river.

Calathus fuscus, F. Mr. Gregson records the capture of two specimens of this species in Patrick Wood, Bromborough.

Calathus mollis, Marsh. Abundant on the sandhills.

Calathus melanocephalus L. Abundant everywhere.

Calathus piceus, Marsh. In woods, local and apparently not common.

Taphria nivalis, Panz. Local, and not common where it does occur. I have only once taken it freely, at West Derby, in a dry ditch-bottom ; it has also occurred on the banks of the Alt, at Hightown (C.S.G.); Flaybrick Hill (J.W.E.); Eastham (R.W.); and West Kirby (A.H.May).

Anchomenus junceus, Scop., = *A. angusticollis*, F. Occasional in damp places.

Anchomenus dorsalis, Müll., = *A. prasinus*, Thunb. Abundant.

Anchomenus albipes, F. Abundant in wet places.

Anchomenus marginatus, L. Common and generally distributed in damp places, especially in damp hollows among the Wallasey sandhills.

Anchomenus ericeti, Panz. On the margin of muddy places on the mosses (J. Chappell).

Anchomenus parumpunctatus, F. Abundant.

Anchomenus viduus, Panz. The type form is very scarce in our district, but the var. *moestus*, Dufts, occurs sparingly.

Anchomenus atratus, Dufts. Generally distributed, but not common.

Anchomenus piceus, L. "Eastham and Hooton, scarce" (C. S. G.).

Anchomenus gracilis, Gyll. Mr. Wilding has taken a specimen of this species under bark at Eastham.

Anchomenus fuliginosus, Panz. The most frequent of this division of the genus, occurring in damp places in widely separated localities.

Anchomenus puellus, Dej. Two specimens only have been recorded from the district: one by Mr. F. Archer, obtained by shaking bundles of dried reeds on Bidston Marsh (Scrap Book); one taken by Mr. Wilding at West Derby.

Olisthopus rotundatus, Payk. Frequent about hilly ground, such as Bidston and Storeton.

Lebia chlorocephala, Hoff. Recorded only by Mr. Gregson, from the banks of the Alt, at Sefton.

Demetrias unipunctatus, Germ. Recorded by Mr. Gregson as occurring on the Wallasey sandhills.

Demetrias atricapillus, L. Abundant on the sandhills and elsewhere, on herbage.

Dromius linearis, Ol. Abundant on herbage, whence it is obtained by sweeping.

Dromius meridionalis, Dej. Frequent under bark, especially of fir.

Dromius agilis, F. Found under bark, between Waterloo and Crosby, by Mr. Kinder.

Dromius quadrimaculatus, L. Common under bark of oak in Eastham Wood, and occasionally elsewhere.

Dromius quadrinotatus, Panz. In similar situations, but scarcely so common as the preceding species.

Dromius nigriventris, Thoms. I discovered this species on Bidston Hill, in February, 1882, and have since taken it there on several occasions; Mr. Wilding has found it at Thurstaston. It occurs under ling and heath, among the dead leaves.

Dromius melanocephalus, Dej. Frequently taken by indiscriminate sweeping of roadside herbage.

Blechrus maurus, Sturm. Mr. Gregson records this species from the sandhills (Wallasey?). I once found it in abundance at the north end of Wallasey Pool, dashing about, as I think Mr. Rye describes it, like "an animated grain of gunpowder."

Metabletus foveola, Gyll. Abundant among dead leaves of the dwarf sallow on the sandhills on both sides of the Mersey; also on Flaybrick Hill, &c.

Cymindis vaporariorum, L. The presence of a specimen

of this uncommon species in the collection of beetles at the Liverpool Free Public Museum, with the locality "Heswall" attached to it, and obtained there under heath, by the Rev. H. H. Higgins, stimulated Mr. Smedley to search for the species in that locality, and with a successful result. Both he and Mr. Wilding have taken it freely there in spring and autumn, and I was fortunate in finding two specimens in a similar situation on Oxton Common in October, 1885.

Broscus cephalotes, L. Common on the shores of the Mersey, under driftwood, &c.

Chlænius nigricornis, F. Banks of the Birket, and from Knowsley Quarry, in April and May (C. S. G.).

Harpalus azureus, F. Wallasey Pool (C. S. G.).

Harpalus rupicola, Sturm. The specimens which have been previously recorded as *puncticollis*, at least those in my own and Mr. Gregson's collections, appear to be uniformly *rupicola*. The species occurs sparingly at Wallasey, Hightown, &c.

Harpalus rufibarbis, F. I have taken two specimens of this species in the neighbourhood, one at Spital, the other at Wallasey.

Harpalus ruficornis, F. Abundant.

Harpalus proteus, Payk. = *H. æneus*, F. Very abundant and variable.

Harpalus latus, L. Frequent on Bidston Hill and on Heswall Heath.

Harpalus neglectus, Dej. Occasional on the Wallasey sandhills, and on the shore at Hightown.

Harpalus tardus, Panz. Not common. It has occurred between Crosby and Waterloo, on the shore; on the Wallasey sandhills and on Bidston Hill.

Harpalus serripes, Schön. I took a female of this species on the Wallasey sandhills in March, 1882.

Harpalus anxius, Dufts. Frequent on the coast sandhills.

Stenolophus elegans, Dej. Two specimens of this species on the banks of the Alt, at Hightown, in June, 1859 (C. S. G.).

Acupalpus dorsalis, F. Mr. Wilding has quite recently taken a specimen of this species on the shore at Hightown.

Acupalpus meridianus, L. Occasional.

Bradycellus cognatus, Gyll. Bidston and Flaybrick Hills.

Bradycellus distinctus, Dej. Taken by Mr. Smedley at the edge of a pit between Liscard and Wallasey, in May, 1882; and by myself, about the same time, at Bromborough.

Bradycellus verbasci, Dufts., = *B. fulvus*, Marsh. Common, and generally distributed.

Bradycellus harpalinus, Dej. Abundant on Bidston and Flaybrick Hills, and on Oxton Common, among dead leaves of heath.

Bradycellus similis, Dej. Abundant, along with the preceding species, in autumn and spring.

Dichirotrichus pubescens, Payk. Abundant under rejectamenta on the shores of the Mersey and Dee.

Anisodactylus binotatus, F. "Wallasey Pool, under stones" (C. S. G.). Mr. Smedley took specimens flying in the sunshine at Hightown, near the mouth of the Alt. July.

HYDRADEPHAGA.

Haliplidæ.

Haliplus obliquus, F. Local, but common where it does occur, as in the Fender, Bidston Marsh; and in pits at the north end of the town (F. K.).

Haliplus confinis, Steph. I took a specimen, some years ago, in a clay-pit behind Wavertree Park, and Mr. Kinder took it freely with the preceding species.

Haliplus fulvus, F. In the Alt, at Hightown (J.W.E.); freely with the preceding species (F.K.); Rock Ferry (F. Archer).

Haliplus flavicollis, Sturm. Taken by Mr. Kinder in pits about Kirkdale.

Haliplus fluviatilis, Aubé. Lydiate, Hightown, and in ditches near Moreton Station (J.W.E.). Mr. Kinder took a few about Westminster Road, in clay-pits.

Haliplus ruficollis, De Geer. Abundant.

Haliplus striatus, Sharp. I have taken two specimens of this species (?) along with *ruficollis*—I think at Liscard.

Haliplus lineatocollis, Marsh. Common, and generally distributed.

Dytiscidæ.

Hyphydrus ovatus, L. Local. I used to take this species commonly behind Wavertree Park, and I have met with a few specimens in widely separated localities. Recorded also from Gill Moss, Deysbrook and Rainford (C.S.G.).

Hydroporus reticulatus, F. Taken freely, in clay-pits about Stanley Road, by F. Kinder; ditches near the Altcar Rifle Ground (F. Archer).

Hydroporus inæqualis, F. Common.

Hydroporus decoratus, Gyll. Recorded by Mr. Gregson, whose specimens I have in my collection, from Patrick Wood, Bromborough.

Hydroporus picipes, F. Three specimens at Kirkdale (F.K.).

Hydroporus pictus, F. Local. River Birket, near the Upton Road (C.S.G.); Westminster Road, in pits (F.K.); Liscard and Moreton (J.W.E.).

Hydroporus lepidus, Ol. Taken at New Brighton, Altcar and Crosby, by Mr. F. Archer, and in the latter locality by myself.

Hydroporus rivalis, Gyll. Formerly in clay-pits behind Wavertree Park (J.W.E.); Crosby (C.S.G.).

Hydroporus septentrionalis, Gyll. Recorded from Bromborough Pool (C.S.G.); near Westminster Road, Kirkdale, freely (F.K.).

Hydroporus Davisii, Curt. "Bidston Marsh, freely, in spring" (C. S. G).

Hydroporus duodecimpustulatus, Ol. Ditches at Huyton, Knowsley and Bebington (C.S.G.).

Hydroporus depressus, F. Generally distributed, but not common.

Hydroporus assimilis, Payk. "This species, first identified here by Dr. Schaum, from specimens taken by the late Mr. Johnson and myself in 1840, in Mosslake Fields, has not been taken since this ground was built upon" (C.S.G.). Behind Wavertree Park, in 1875 (J.W.E.); Kirkdale (F.K.); Liscard (R.W.).

Hydroporus dorsalis, F. Local. "Bidston Marsh and Frankby" (C.S.G.); abundant in a pit at Moreton, April (J.W.E.); freely at Tranmere (W. Gardner); and at Liscard (R.W.).

Hydroporus memnonius, Nic. Kirkdale (F.K.); recorded (*in litt*) by Mr. Chappell from a small pool in the Crosby sandhills, in April; I have taken it in a pond in a quarry at West Derby.

Hydroporus Gyllenhalii, Schiödte. I have taken this very distinct species on the Wallasey sandhills and in drains on Simmonswood Moss.

Hydroporus erythrocephalus, L. "Bidston Marsh and Frankby" (C.S.G.); Crosby (F. Archer); Hightown (J.W.E.).

Hydroporus lituratus, F. One specimen of this species behind Leasowe Embankment, in March, 1886 (J.W.E.).

Hydroporus planus, F. Abundant.

Hydroporus melanocephalus, Steph. Common, and generally distributed.

Hydroporus nigrita, F. Mr. Kinder took a few specimens of this usually common species about Kirkdale, and I have one taken somewhere in the district.

Hydroporus celatus, Clark. Some years ago I found this usually rare species in water trickling down the clay banks at Otterspool. Easily recognised by its entirely red antennæ and the short and broad anterior tibiæ.

Hydroporus melanarius, Sturm. Taken along with *Gyllenhalii* on Simmonswood Moss (J.W.E.).

Hydroporus tristis, Payk. Simmonswoood, in a ditch by the roadside (J.W.E.).

Hydroporus palustris, L. Abundant.

Hydroporus angustatus, Sturm. Pits near Westminster Road, Kirkdale (F.K.).

Hydroporus lineatus, F. River Birket, near the Upton Road (C.S.G.); Kirkdale (F.K.); abundant at Moreton (J.W.E.).

Noterus sparsus, Marsh. Local, but common where it does occur, as at New Ferry, Liscard, &c.

Laccophilus minutus, L. Frequent in ponds.

Laccophilus hyalinus, De Geer. "Bidston Marsh and Bromborough" (C.S.G.).

Colymbetes fuscus, L. Common in pits, and very abundant in "flashes" of water on the sandhills beyond Wallasey.

Colymbetes Grapii, Gyll. A single specimen, taken in Mosslake Fields by Mr. Gregson, is now in my collection.

Colymbetes pulverosus, Steph. "Ponds and ditches around Old Swan, Knotty Ash, &c." (C.S.G.).

Colymbetes bistriatus, Berg. Recorded by Mr. Gregson as a former inhabitant of Mosslake and Parliament Fields.

Colymbetes exoletus, Forst. I picked up a dead specimen

of this species on the bank of the Alt, at Hightown, in May, 1882.

Ilybius fenestratus, F. "Clubmoor and Childwall" (C. S. G.); sparingly behind Wavertree Park, in pits (J.W.E.).

Ilybius fuliginosus, F. Common.

Ilybius ater. De Geer. Frequent.

Ilybius obscurus, Marsh. I have a specimen of this species, which I took in the Fender; and Mr. Archer records the capture, in a brook at Little Brighton, of the var. *sexdentatus*, Schiödte.

Ilybius œnescens, Thoms. Under the name of *angustior*, Gyll., Mr. Gregson records this species as "formerly plentiful in the Mosslake fields."

Liopterus agilis, F. Pits and ditches near Wavertree (C.S.G.); pits by the roadside between Liscard and Wallasey, and at Moreton (J.W.E.).

Agabus bipustulatus, L. Abundant.

Agabus chalconotus, Panz. Taken in ditch near Moreton Station, in March, 1886 (J.W.E.).

Agabus Sturmii, Gyll. Not uncommon in pools among the Wallasey and Crosby sandhills, and at Moreton.

Agabus paludosus, F. Mr. F. Kinder took a specimen somewhere in the district—he believed at Crosby.

Agabus guttatus, Payk. Not uncommon in running water.

Agabus nebulosus, Forst. Abundant.

Agabus conspersus, Marsh. Crosby (J.W.E.); Hightown (F. Archer).

Agabus femoralis, Payk. Formerly taken in Parliament Fields by Mr. Gregson.

Agabus maculatus, L. Recorded as common by Mr. Gregson.

Dytiscus marginalis, L. Common.

Dytiscus punctulatus, F. A few specimens of this species in a pond among the sandhills beyond Wallasey village (J.W.E.); ponds near Liscard (R.W.).

Acilius sulcatus, L. Generallly distributed, but scarcely common.

Gyrinidæ.

Gyrinus natator, Scop. Abundant. All the specimens I have seen from this neighbourhood are of the form known as *mergus*, Ahr., distinguished by the distinct but much finer inner striæ.

Gyrinus bicolor, Payk. Recorded by Mr. Archer from ditches on Altcar Rifle Ground, and by Mr. Gregson from between Bromborough and Raby. The Rev. W. W. Fowler refers to the record of this species at Liverpool as doubtful; I have Mr. Gregson's specimen, and it is not the following species, as suggested by Fowler, but an undoubted *bicolor*.

Gyrinus distinctus, Aubé. Taken by Mr. Chappell behind Leasowe Embankment, in April. Acting under his directions, I have myself found it in that neighbourhood.

Gyrinus marinus, Gyll. "In Wallasey Pool, before it was converted into docks" (C.S.G.); Altcar (F. Archer); Liscard (J.W.E.).

CLAVICORNIA.

Hydrophilidæ.

Hydrobius fuscipes, L. Abundant.

The race *H. picicrus*, Sharp, is about as common as the type in this neighbourhood, and I find that this form, distinguished by its pitchy legs, and shorter and more convex shape, stands in some collections as *H. oblongus*.

Enochrus bicolor, Payk. In a pit near Westminster Road (F.K.); River Alt, at Hightown, in 1884 (J.W.E.).

Anacæna limbata, F. Abundant.

Anacæna variabilis, Sharp. Common.

Philhydrus testaceus, F. "Common in pits near Westminster Road" (F. K.); frequent near Moreton Station (J.W.E.).

Philhydrus melanocephalus, Ol. With the preceding species (F. K.).

Philhydrus suturalis, Sharp. A few specimens taken along with *ovalis* at Moreton.

Philhydrus ovalis, Thoms. "Taken freely in a drain between Leasowe Embankment and Moreton Station" (J. Chappell, *in litt.*). I took it in abundance in the same locality in March, 1886, and April, 1888 (J.W.E.).

Laccobius minutus, L. Recorded from the Fender, Bidston Marsh, by A. H. May, but whether the type form or the variety (species?) *bipunctatus*, F., Mr. May does not say. I have never taken the true *minutus*, but have a specimen of *bipunctatus* captured in the Alt, at Hightown.

Laccobius nigriceps, Thoms. I have not taken the type nearer than Llangollen, though stated by the Rev. W. W. Fowler to be the commonest of the genus; of the form *alutaceus*, Thoms, I have a few specimens from the Wallasey sandhills.

Berosus affinis, Brullé. Local. Formerly abundant in the clay-pits behind Wavertree Park, but I have not met with a specimen for some time. Mr. Kinder took a few about Kirkdale.

Limnebius truncatellus, Thunb. Crosby (F. Archer); Moreton and Liscard (J.W.E.).

Chætarthria seminulum, Payk. I have twice met with this species on the Wallasey sandhills.

Helophorus nubilis, F. Crosby shore (F.K.). Mr. Archer took this species on Bidston Marsh, in November, 1862.

Helophorus intermedius, Muls. Crosby, September (F. Archer).

Helophorus aquaticus, L. Abundant. In my series I cannot find any of the apparently common var. *æqualis*, Thoms.

Helophorus Mulsanti, Rye. The specimen recorded in my former article under this name is, I find, *H. æneipennis*. Fowler records *Mulsanti* as being taken commonly here by Mr. Crotch.

Helophorus griseus, Thoms., = *H. affinis*, Marsh. Occasional.

Helophorus granularis, Thoms., = *H. brevipalpis*, Bedel. Abundant.

Helophorus æneipennis, Thoms. Altcar Rifle Ground (F. Archer). I have taken it abundantly in rejectamenta brought down the Alt after heavy rain; but all the specimens are of the normal type.

Helophorus arvernicus, Muls. I have a specimen taken some eight or nine years ago among *granularis*.

Helophorus dorsalis, Marsh. Altcar Rifle Ground (F. Archer).

Hydrochus angustatus, Germ. Freely in clay-pits near Westminster Road (F.K.); Leasowe (R.W.); Liscard (J.W.E.).

Octhebius margipallens, Latr. Taken sparingly by Mr. Chappell in a drain near Moreton Station.

Octhebius pygmæus, F. Moreton (J.W.E.).

Octhebius bicolon, Germ. Abundant.

Octhebius rufimarginatus, Steph. I took a pair of this species on Bidston Marsh, in 1882.

Hydræna riparia, Kug. I have taken several specimens near Leasowe.

Cyclonotum orbiculare, F. Common on the weedy banks of ponds, and at the mouth of the Alt at Hightown.

Sphæridium scarabæoides, L. Abundant in dung.

Sphæridium bipustulatum, F. Both the type and the var. *marginatum*, F., are abundant in dung.

Cercyon obsoletus, Gyll. Frequent in dung, especially on the sandhills.

Cercyon hæmorrhoidalis, F. Abundant.

Cercyon aquaticus, Muls A single specimen at Leasowe (J.W.E.).

Cercyon flavipes, F. Abundant. This and *melanocephalus* are by far the most abundant of the genus with us.

Cercyon lateralis, Marsh. I have taken a few specimens in the district, and Mr. Kinder took it freely about Kirkdale.

Cercyon littoralis, Gyll. Very abundant on the shore, under seaweed, &c.

Cercyon unipunctatus, L. Common.

Cercyon quisquilius, L. Common.

Cercyon melanocephalus, L. Abundant.

Cercyon terminatus, Marsh. Occasionally at Wallasey (J.W.E.); common at Litherland (F.K.).

Cercyon pygmæus, Ill. Abundant.

Cercyon nigriceps, Marsh. A specimen which alighted on a book I was reading,in St. Anne Street, is the only one I have taken in the district.

Cercyon lugubris, Payk. I have twice taken this species in the district, once at Hightown.

Cercyon analis, Payk. Generally distributed, but scarcely common.

Megasternum boletophagum, Marsh. Common.

Cryptopleurum atomarium, F. Common.

Silphidæ.

Clambus armadillo, De Geer. I took a specimen of this tiny species in moss from a wall at Bromborough, last January.

Agathidium varians, Beck. Wallasey, a single specimen taken in March, 1884 (J.W.E.).

Agathidium marginatum, Sturm. Two specimens from the Wallasey sandhills (J.W.E.).

Leiodes humeralis, F. A single specimen at Crosby (R.W.).

Hydrobius punctatissimus, Steph. Four specimens by nocturnal sweeping at Crosby (R. W.); Wallasey, a single specimen (J.W.E.).

Anisotoma dubia, Kug. Recorded from New Brighton by Mr. Archer. I have a specimen taken in the district some years ago.

Anisotoma calcarata, Er. Common.

Necrophorus humator, F. Common in carrion. The most abundant of the genus with us.

Necrophorus ruspator, Er. Local. Bromborough (J.H.S.); Wallasey (J. W.E.).

Necrophorus mortuorum, F. I have taken a single specimen at Eastham.

Necrophorus vespillo, L. Abundant on the Wallasey sandhills, in carrion.

Necrodes littoralis, L. Not common. I have taken several specimens under a dead animal on the Aigburth shore, and Mr. Wilding has found it at Wallasey.

Silpha rugosa, L. Abundant in carrion.

Silpha sinuata, F. Common on the sandhills.

Silpha tristis, Ill. Crosby, May, 1862 (F. Archer).

Silpha atrata, L. Mr. Wilding has taken a specimen at Crosby.

Choleva angustata, F. Mr. Smedley took a pair at Storeton, in February, 1882.

Choleva cisteloides, Fröhl. A specimen taken at West Kirby, in March, 1883, is all I have seen.

Choleva agilis, Ill. I have taken two specimens of this species on Bidston Marsh, and one at Eastham.

Choleva fusca, Panz. Common at Wallasey, in traps baited with meat.

Choleva nigricans, Spence. Abundant with the last.

Choleva morio, F. Crosby and Spital (J.W.E.).

Choleva nigrita, Er. Common.

Choleva tristis, Panz. Common.

Choleva grandicollis, Er. I took a specimen at Spital, in November, 1883.

Choleva Kirbyi, Spence. A specimen at Hightown (J.W.E.).

Choleva chrysomeloides, Panz. Common.

Choleva Watsoni, Spence. Wallasey, in May, 1883 (J.W.E.).

Choleva velox, Spence. Abundant in traps set on the Wallasey sandhills.

Ptomaphagus sericea, Panz. Common.

Colon latum, Kr. Eastham, in moss (J.W.E.).

Scydmænidæ.

Scydmænus collaris, Müll. Tolerably common in moss, &c.

Scydmænus exilis, Er. Under fir-bark at Eastham, June, 1883 (J.W.E.).

Scydmænus hirticollis, Ill. Two specimens occurred to me at Wallasey, in March, 1884.

Pselaphidæ.

Tychus niger, Payk. Under bark at Bromborough (J.W.E.).

Bryaxis hæmatica, Reich. I have a pair taken in moss from a wall at Eastham, in November, 1882.

Euplectus sanguineus, Aubé. Under bark of fir-railings on Bidston Hill, in February, 1882 (J.W.E.).

STAPHYLINIDÆ.

Autalia impressa, Ol. Mr. Kinder records having taken three specimens in the district.

Autalia rivularis, Grav. Under bark at Bromborough, in May, 1883 (J.W.E.).

Falagria sulcata, Payk. Under bark of fir, at Bidston (J.W.E.).

Falagria sulcatula, Grav. I have taken several specimens at Wallasey.

Falagria obscura, Grav. In nests of the black ant, at Eastham, June, 1863 (F. Archer); two specimens along with *sulcata* (J.W.E.).

Bolitochara obliqua, Er. Not rare under bark of felled trees at Eastham.

Phytosus Balticus, Kr. Abundant on the shore at Crosby and Hightown about high-water mark. Summer.

Ocalea castanea, Er. I took a specimen at Eastham in November, 1882.

Ischnoglossa rufopicea, Kr. Common under bark at Eastham.

Leptusa fumida, Er. Common at Spital and Eastham, under bark.

Aleochara ruficornis, Grav. I took a specimen of this fine and scarce insect in Eastham Wood, in May, 1881.

Aleochara fuscipes, Grav. Moderatly common in dung and in carcases on the shore.

Aleochara morion, Grav. Several specimens at Wallasey (J.W.E.).

Aleochara lanuginosa, Grav. Abundant.

Aleochara nitida, Grav. Abundant.

Aleochara obscurella, Grav. Common on the Crosby, New Brighton, and Wallasey shores, in seaweed.

Myrmedonia limbata, Payk. Crosby and Hightown (J.W.E.).

Myrmedonia canaliculata, F. Common on the Crosby and Hightown sandhills.

Callicerus obscurus, Grav. I took a specimen at Wallasey in May, 1883.

Callicerus rigidicornis, Er. Two specimens of this rare species have been taken by me, one at Eastham and one on the shore at Aigburth, both in May, 1883.

Chilopora longitarsis, Er. Hightown shore, among rejectamenta brought down by the Alt, in July, 1883 (J.W.E.).

Oxypoda lividipennis, Mann. Common.

Oxypoda opaca, Grav. Common and generally distributed.

Oxypoda longiuscula, Grav. Bidston Hill and Eastham.

Oxypoda umbrata, Gyll. One specimen taken at Spital in May, 1885.

Oxypoda nigrina, Wat. Several specimens have occurred at Wallasey and Leasowe.

Oxypoda alternans, Grav. Occasionally in fungi in Eastham Wood.

Oxypoda (Ocyusa) incrassata, Muls. I have a single specimen from Eastham.

Homalota insecta, Thoms. One specimen from Hightown, May, 1882.

Homalota luridipennis, Mann. I have two specimens from Hightown.

Homalota hygrotopora, Kr. Mr. Kinder reports the capture of several of this species, but does not mention the locality.

Homalota elongatula, Grav. Spital (J.W.E.).

Homalota volans, Scriba. Common and generally distributed.

Homalota gregaria, Er. Generally distributed and fairly common.

Homalota vestita, Grav. Common, especially near the sea.

Homalota vicina, Steph. Simmonswood Moss, in June, 1885 (J.W.E.).

Homalota graminicola, Grav. Frequent.

Homalota halobrectha, Sharp. Waterloo and Hightown, among seaweed.

Homalota fungivora, Thoms. A specimen at Eastham, in November, 1882 (J.W.E.).

Homalota cæsula, Er. A rare but very distinct species, of which I took a specimen at Leasowe, behind the Embankment, in April, 1883.

Homalota circellaris, Grav. Common.

Homalota plana, Gyll. Recorded from Bootle by Mr. Kinder.

Homalota cuspidata, Er. I took a specimen under fir-bark at Bidston, in October, 1884.

Homalota analis, Grav. Common in moss, &c., and very variable.

Homalota parallela, Mann. Wallasey, in April, 1883 (J.W.E.).

Homalota aquatica, Thoms. One at Spital and one at Hightown (J.W.E.).

Homalota trinotata, Kr. Bootle (F. K.); Wallasey (J.W.E.).

Homalota triangulum, Kr. In the same localities as the preceding species.

Homalota boletobia, Thoms. Wallasey, in May, 1882 (J.W.E.).

Homalota divisa, Märk. Hightown (J.W.E.).

Homalota nigricornis. One specimen from Wallasey.

Homalota atricolor, Sharp. Abundant at Wallasey.

Homalota nigra, Kr. Abundant.

Homalota longicornis, Grav. Common.

Homalota lævana, Muls. Eastham (J.W.E.).

Homalota cinnamoptera, Thoms. Eastham, a single specimen (J.W.E.).

Homalota villosula, Kr. One specimen from Spital (J.W.E.).

Homalota atramentaria, Gyll. Abundant.

Homalota parva, Sahl. Bidston and Wallasey, occasional.

Homalota melanaria, Sahl. Abundant.

Homalota aterrima, Grav. Common.

Homalota pygmæa, Grav. One from Wallasey is all I have seen here.

Homalota orbata, Er. I have taken two specimens, one at Wallasey, the other at Eastham.

Homalota fungi, Grav. Abundant in moss, &c.

Homalota clientula, Er. Among the preceding species.

Phlœophora reptans, Grav. Common under bark at Eastham.

Oligota pusillima, Grav. I have a specimen taken somewhere in the district.

Oligota atomaria, Er. Abundant in moss about Storeton and Bromborough, during the winter.

Oligota punctulata, Heer. I have taken one specimen among *atomaria*.

Gyrophæna affinis, Sahl. Eastham Wood, in fungi.

Hypocyptus longicornis, Payk. Frequent in moss growing on walls at Bromborough.

Hypocyptus læviusculus, Mann. One specimen from Wallasey, in March, 1883.

Hypocyptus pygmæus, Kr. I have taken a few that I believe to be this species in moss at Eastham and Spital.

Cilea silphoides, L. Tolerably common about dung-heaps, &c.

Tachinus humeralis, Grav. Two or three specimens were taken in the district by Mr. Kinder.

Tachinus flavipes, Fab. Mr. Wilding has quite recently taken a single specimen at Crosby.

Tachinus rufipes, De G. Abundant.

Tachinus pallipes, Grav. I have a specimen that I took in Eastham Wood, in September, 1885, and another, immature, taken several years ago in the district.

Tachinus subterraneus, L. Occasional.

Tachinus marginellus, F. Abundant.

Tachinus laticollis, Grav. I have three specimens of this doubtfully distinct species taken among *marginellus*.

Tachyporus obtusus, L. Abundant.

Tachyporus solutus, E. I have taken about half a dozen in the district.

Tachyporus chrysomelinus, L. Abundant.

Tachyporus humerosus, Er. Occasional.

Tachyporus hypnorum, F. The most abundant of the genus.

Tachyporus pusillus, Grav. Common.

Tachyporus brunneus, F. Common on the banks of the Fender, Bidston Marsh.

Conurus littoreus, L. A single specimen at Wallasey.

Conurus pubescens, Payk. Common about grass-roots, &c.

Conurus lividus, Er. Common about grass-roots, &c.

Bolitobius atricapillus, Steph. Mr. Wilding and myself have taken this species in moss growing on a wall at Eastham.

Bolitobius trinotatus, Er. Occasionally in fungi and rotten wood about Eastham.

Bolitobius pygmæus, F. Rock Ferry (F. Archer).

Megacronus cingulatus, Mann. A specimen captured somewhere in this district by F. Kinder.

Megacronus analis, Payk. Frequent.

Megacronus inclinans, Grav. A scarce species, of which I have taken a specimen among dead leaves in Eastham Wood.

Mycetoporus splendidus, Grav. Recorded from widely separated localities: Rock Ferry (F. Archer); West Derby (R. W.); and Wallasey (J.W.E.).

Mycetoporus lucidus, Er. A specimen by sweeping near Walton Gaol (F. K.); Eastham, in September, 1884 (J.W.E.).

Mycetoporus longulus, Mann. Hightown, Wallasey and Leasowe (J.W.E.).

Mycetoporus lepidus, Grav. Generally distributed.

Mycetoporus nanus, Grav. I took a specimen of this scarce species at Crosby, in April, 1882.

Mycetoporus splendens. Marsh. Several specimens at Wallasey (F. K.).

Heterothops binotata, Steph. Frequent under seaweed, &c. on the shore at Hightown and Wallasey.

Quedius fulgidus, F. The dark form (*Q. temporalis*, Thoms. = *mesomelinus*, Marsh.) is generally distributed throughout the district. Of the form *quadripunctatus*, Thoms., with bright red elytra, I have two specimens taken in the district, one in a cellar in Liverpool.

Quedius cruentus, Ol. Formby, in September, 1885 (J.W.E.).

Quedius impressus, Panz. Common.

Quedius molochinus, Grav. Frequent.

Quedius tristis, Grav. Common.

Quedius fuliginosus, Grav. Abundant.

Quedius nigriceps, Kr. Eastham and the fir plantations at Storeton (J.W.E.).

Quedius peltatus, Er. Eastham (R.W.) and Aigburth (J.W.E.).

Quedius umbrinus, Er. I have a single specimen from Aigburth.

Quedius maurorufus, Grav. Common on the banks of the Alt at Hightown.

Quedius rufipes, Grav. Common.

Quedius semiæneus, Steph. Fields about Kirkdale (F.K.); Wallasey and Bidston Marsh (J.W.E.).

Quedius boops, Grav. Frequent in dry places.

Quedius scintillans, Grav. I took a specimen in Eastham Wood, in June, 1883.

Creophilus maxillosus, L. Common.

Leistotrophus nebulosus, F. One specimen from Wallasey (J.W.E.).

Leistotrophus murinus, L. A specimen taken at Crosby by myself.

Staphylinus pubescens, De G. Common on the Wallasey sandhills.

Staphylinus stercorarius, Ol. Mr. Wilding records a specimen from the Crosby sandhills.

Staphylinus cæsareus, Ceder. One specimen from Simmonswood Moss (J.W.E.).

Ocypus olens, Müll. Abundant.

Ocypus brunnipes, F. Occasional.

Ocypus fuscatus, Grav. Not common. Several at West Derby (R.W.); Childwall and Wallasey (J.W.E.).

Ocypus cupreus, Rossi. Common.

Ocypus ater, Grav. I once took this species in abundance among rubbish at Bromborough Pool, and have occasionally met with it elsewhere.

Ocypus morio, Grav. Moderately common.

Ocypus compressus, Marsh. Crosby (F. Archer), Bebington (J.H.S.), and Leasowe (J.W.E.).

Philonthus splendens, F. Abundant in Eastham Wood, in November, 1882 (J.W.E.).

Philonthus intermedius, Boisd. Two specimens taken by myself at Wallasey are all I have seen from this district.

Philonthus laminatus, Creutz. Abundant.

Philonthus æneus, Rossi. Abundant.

Philonthus carbonarius, Gyll. Leasowe and Wallasey, in spring.

Philonthus decorus, Grav. Common in Eastham Wood, and easily recognised by its dull bronze colour.

Philonthus politus, F. Common.

Philonthus umbratilis, Grav. West Derby and Wallasey (J.W.E.).

Philonthus marginatus, F. Common.

Philonthus varius, Gyll. The type form, with greenish bronze elytra, is abundant; I have never met with the variety *bimaculatus*, Grav.

Philonthus albipes, Grav. I have taken a single specimen at Leasowe.

Philonthus sordidus, Grav. Generally distributed, but not common.

Philonthus fimitarius, Grav. Common.

Philonthus cephalotes, Grav. Generally distributed; common at Wallasey.

Philonthus ebeninus, Er. Common.

Philonthus fumigatus, Er. Taken freely at West Derby by Mr. Wilding; also at Hightown by Mr. Wilding and myself.

Philonthus sanguinolentus, Grav. Wallasey sandhills (R.W., J.W.E.).

Philonthus bipustulatus. Panz. Wallasey, abundant (R.W., J.W.E.); Mr. Kinder used to take this species freely on sallows at Crosby, in spring.

Philonthus scybalarius, Nord. I have taken one specimen in the district, I believe at Storeton.

Philonthus varians, Payk. Abundant.

Philonthus discoideus, Grav. In abundance in manure from a stable-midden at the back of my house in Brougham Terrace; I have also met with it at Crosby.

Philonthus ventralis, Grav. I have taken several specimens in the district.

Philonthus vernalis, Grav. Wallasey (R.W., J.W.E.); Hightown (J.W.E.).

Philonthus micans, Grav. Taken at Formby by myself in the autumn of 1886.

Philonthus trossulus, Nord. Common.

Philonthus puella, Nord. I have taken two specimens, one at Bidston, the other at Wallasey.

Cafius xantholoma, Grav. Taken at Hightown by Mr. Archer, and behind Leasowe Embankment by Mrs. Ellis.

Actobius signaticornis, Rey. I took a specimen of this rare species at Hightown in May, 1883.

Actobius procerulus, Grav. A single specimen taken at Aigburth, in May, 1883, is all I have seen.

Xantholinus glabratus, Grav. Common.

Xantholinus punctulatus, Payk. Fairly common.

Xantholinus ochraceus, Gyll. Common.

Xantholinus atratus, Heer. I have two specimens collected in the neighbourhood, one being from Wallasey.

Xantholinus tricolor, F. I have a specimen taken somewhere in the district.

Xantholinus linearis, Ol. Both the type and the form known as *longiventris*, Heer, are abundant, especially on the coast sandhills.

Leptacinus batychrus, Gyll. Litherland (F.K.).

Leptacinus linearis, Grav. Also recorded by Mr. Kinder from Litherland.

Othius fulvipennis, F. Common.

Othius melanocephalus, Grav. Common.

Othius myrmecophilus, Kies. Not uncommon about Eastham.

Lathrobium brunnipes, F. Common.

Lathrobium boreale, Hoch. Common.

Lathrobium elongatum, L. Common.

Lathrobium multipunctum, Grav. Generally distributed, but scarcely common.

Lathrobium quadratum, Payk. One specimen captured at Hightown.

Lithocharis ochracea, Grav. Common.

Lithocharis melanocephala, F. Recorded from Litherland by Mr. Kinder; I have taken two or three in the district.

Stilicus affinis, Er. Common on the banks of ponds, &c.

Stenus biguttatus, L. Taken on the shore of the Mersey, above Eastham, by Mr. Smedley.

Stenus guttula, Müll. Eastham (J.H.S.); at Hightown, on the bank of the Alt (J.W.E.).

Stenus bimaculatus, Gyll. Hightown and Spital (J.W.E.).

Stenus Juno, F. Not uncommon in damp places.

Stenus foveiventris, Fairm. Generally considered one of the common species of the genus, but I have only met with a few specimens, about Spital.

Stenus melanopus, Marsh. Spital and Eastham (J.W.E.).

Stenus canaliculatus, Gyll. Not uncommon.

Stenus æmulus, Er. I have an undoubted example of this species, generally considered a fen insect, which I took at Eastham.

Stenus pusillus, Steph. A few specimens have occurred about Spital.

Stenus speculator, Lac. Common.

Stenus providus, Er., var. *Rogeri*, Kr. Occasional.

Stenus crassiventris, Thoms. I have taken the type form of this species about Liscard, and I have two specimens from the Wallasey sandhills which I believe to be the var. *littoralis*, Thoms.

Stenus nigritulus, Gyll. West Derby, a single specimen.

Stenus binotatus, Ljun. I have a specimen taken somewhere in the district.

Stenus pubescens, Steph. Wallasey and Moreton (J.W.E.).

Stenus pallitarsis, Steph. I took a specimen at Moreton recently (J.W.E.).

Stenus rusticus, Er., = *picipes*, Steph. Not uncommon.

Stenus tempestivus, Er. I have a specimen captured at Spital.

Stenus subæneus, Er. Crosby (F. Archer); a specimen at Aigburth, in May, 1883, and one more recently at Wallasey (J.W.E.).

Stenus impressipennis, Duv. Crosby (F. Archer).

Stenus impressus, Germ. Tolerably common.

Stenus cicindeloides, Grav. Common.

Stenus similis, Herbst. Common.

Stenus tarsalis, Ljun. Fairly common.

Stenus paganus, Er. Frequent.

Stenus latifrons, Er. Common.

Oxyporus rufus, L. Mr. Kinder has taken a specimen in a fungus in the neighbourhood of the North Docks; and Mr. A. O. Walker has taken it freely in fungi in Delamere Forest, a few miles beyond our boundary. It will probably be found in the woods about Hooton and Bromborough if looked for in autumn.

Bledius arenarius, Payk. Common on the Crosby shore, where it forms shallow burrows in the sand above high-water mark. Along with the type there occurs a form, not quite so broad in build, and with the elytra dark except the extreme sides and apex. I have met with no intermediate varieties.

Bledius subterraneus, Er. Crosby (F. Archer).

Bledius fuscipes, Rye. "Crosby, April 15th, 1870, the female at the bottom of a burrow 1 to 1½ inches deep; the male in a transverse burrow close to the mouth" (J. Kidson Taylor, Entomologists' Monthly Magazine, vol. viii., p. 10). I have taken a few specimens at Crosby and one at Wallasey.

Bledius fracticornis, Pk. Bidston Marsh and Hightown (F. Archer); Wallasey, and in a wet place in a sandy lane at Bebington (J.W.E.).

Platystethus arenarius, Fourc. Abundant.

Oxytelus rugosus, F. Abundant.

Oxytelus insecatus, Grav. I have taken about half a dozen specimens in the neighbourhood.

Oxytelus laqueatus, Marsh. Common.

Oxytelus sculptus, Grav. Frequent.

Oxytelus sculpturatus, Grav. Common.

Oxytelus inustus, Grav. I have a single specimen from Wallasey.

Oxytelus maritimus, Thoms. Common on the shore at Wallasey and Crosby, under seaweed, &c.

Oxytelus nitidulus, Grav. Common.

Oxytelus complanatus, Er. Occasional.

Oxytelus tetracarinatus, Block, = *depressus*, Grav. Abundant.

Trogophlœus bilineatus, Steph. One at Hightown, one at Wallasey (J.W.E.).

Trogophlœus fuliginosus, Grav. I have a specimen taken on the clay-banks at Otterspool.

Syntomium œneum, Müll. In moss growing on a wall at Eastham (J.W.E.).

Coprophilus striatulus, F. Mr. Wilding has taken two of this species at Fazakerley, under rubbish, and a specimen on the Wallasey sandhills. I once took a mutilated specimen out of a spider's web at Liscard.

Lesteva Sharpi, Rye. Frequent in wet places, especially about the mouth of the Alt.

Lesteva pubescens, Mann. In a wet place on the Otterspool shore (J.W.E.).

Lesteva punctata, Er. Common in wet places.

Olophrum piceum, Gyll. Occasional in woods, as at Eastham, Prenton, &c.

Lathrimæum unicolor, Marsh. Frequent.

Micralymma brevipenne, Gyll. Under seaweed at Hoylake (J. Chappell).

Homalium rivulare, Payk. Abundant.

Homalium lævisculum, Gyll. Reported from Hightown by Mr. Archer.

Homalium rugulipenne, Rye. A very local species throughout Britain, but abundant on the Wallasey and Crosby shores, under seaweed, &c.

Homalium fossulatum, Er. Frequent.

Homalium pusillum, Grav. A few specimens under bark at Bidston and Eastham (J.W.E.).

Homalium punctipenne, Thoms. Two specimens from under fir-bark at Storeton (J.W.E.).

Homalium concinnum, Marsh. Mr. Kinder used to take this species freely on the wall of Anfield Cemetery; I have taken in on Bidston Marsh.

Homalium vile, Er. Common under bark.

Homalium florale, Payk. Wallasey (J.W.E.); Rock Ferry (F. Archer).

Homalium striatum, Grav. Common about Eastham and Liscard.

Anthobium ophthalmicum, Pk. Eastham Wood, on flowers of mountain-ash (J.W.E.); Rock Ferry (F. Archer).

Proteinus brevicollis, Er. Common.

Megarthrus depressus, Payk. Common.

Megarthrus affinis, Mill. I have a pair from a wall near Liscard.

Megarthrus denticollis, Beck. Not uncommon on walls about Liscard and Wallasey.

LAWS

OF THE

LIVERPOOL BIOLOGICAL SOCIETY.

I.—The name of the Society shall be the "Liverpool Biological Society," and its object the advancement of Biological Science.

II.—The Ordinary Meetings of the Society shall be held at University College, at Eight o'clock, during the six Winter months, on the second Friday evening in every month, or at such other place or time as the Council may appoint.

III.—The business of the Society shall be conducted by a President, two Vice-Presidents, a Treasurer, a Secretary, and twelve other Members, who shall form a Council; four to constitute a quorum.

IV.—The President, Vice-Presidents, Treasurer, Secretary, and Council shall be elected annually, by ballot, in the manner hereinafter mentioned.

V.—The President shall be elected by the Council (subject to the approval of the Society) at the last Meeting of the Session, and take office at the ensuing Annual Meeting.

VI.—The mode of election of the Vice-Presidents, Treasurer, Secretary, and Council shall be in the form and manner following:—It shall be the duty of the retiring Council at their final meeting to suggest the names of Members to fill the offices

of Vice-Presidents, Treasurer, Secretary, and of four Members who were not on the last Council to be on the Council for the ensuing session, and formally to submit to the Society, for election at the Annual Meeting, the names so suggested. The Secretary shall make out and send to each Member of the Society, with the circular convening the Annual Meeting, a printed list of the retiring Council, stating the date of the election of each Member, and the number of his attendances at the Council Meetings during the past session; and another containing the names of the Members suggested for election, by which lists, and no others, the votes shall be taken. It shall, however, be open to any Member to substitute any other names in place of those upon the lists, sufficient space being left for that purpose. Should any list when delivered to the President contain other than the proper number of names, that list and the votes thereby given shall be absolutely void. Every list must be handed in personally by the Member at the time of voting. Vacancies occurring otherwise than by regular annual retirement shall be filled by the Council.

VII.—Every Candidate for Membership shall be proposed by three or more Members, one of the proposers from personal knowledge. The nomination shall be read from the Chair at any Ordinary Meeting, and the Candidate therein recommended shall be balloted for at the succeeding Ordinary Meeting. Ten black balls shall exclude.

VIII.—When a person has been elected a Member, the Secretary shall inform him thereof, by letter, and shall at the same time forward him a copy of the Laws of the Society.

IX.—Every person so elected shall within one calendar month after the date of such election pay an Entrance Fee of Half a Guinea and an Annual Subscription of One Guinea (except in the case of Student Members); but the Council shall have the power in exceptional cases, of extending the period for such payment. No Entrance Fee shall be payable by Members

elected before October, 1887, or on the re-election of any Member who has already paid one such fee.

X.—The Subscription (except in the case of Student Members) shall be One Guinea per annum, payable in advance, on the day of the Annual Meeting in October.

XI.—Members may compound for their Annual Subscriptions by a single payment of Ten Guineas.

XII.—There shall also be a class of Student Members, paying an Entrance Fee of Two Shillings and Sixpence, and a Subscription of Five Shillings per annum.

XIII.—Resignation of Membership shall be signified *in writing* to the Secretary, but the Member so resigning shall be liable for the payment of his Annual Subscription, and all arrears up to the date of his resignation.

XIV.—The Annual Meeting shall be held on the second Friday in October, or such other convenient day in the month as the Council may appoint, when a Report of the Council on the affairs of the Society, and a Balance Sheet, duly signed by Auditors previously appointed by the Council, shall be read.

XV.—Any person (not resident within ten miles of Liverpool) eminent in Biological Science, or who may have rendered valuable services to the Society, shall be eligible as an Honorary Member; but the number of such Members shall not exceed fifteen at any one time.

XVI.—Captains of vessels and others contributing objects of interest shall be admissible as Associates for a period of three years, subject to re-election at the end of that time.

XVII.—Such Honorary Members and Associates shall be nominated by the Council, elected by a majority at a General Meeting, and have the privilege of attending and taking part in the Meetings of the Society, but not of voting.

XVIII.—Should there appear cause in the opinion of the Council for the expulsion from the Society of any Member, a Special General Meeting of the Society shall be called by the Council for that purpose; and if two-thirds of those voting agree that such Member be expelled, the Chairman shall declare this decision, and the name of such Member shall be erased from the books.

XIX.—Every Member shall have the privilege of introducing one visitor at each Ordinary Meeting. The same person shall not be admissible more than twice during the same session.

XX.—Notices of all General or Special Meetings shall be issued to each Member by the Secretary, at least three days before such Meeting.

XXI.—The President, Council, or any ten Members can convene a Special General Meeting, to be called within fourteen days, by giving notice in writing to the Secretary, and stating the object of the desired Meeting. The Circular convening the Meeting must state the purpose thereof.

XXII.—Votes in all elections shall be taken by ballot, and in other cases by show of hands, unless a ballot be first demanded.

XXIII.—No alteration shall be made in these Laws, except at an Annual Meeting, or a Special Meeting called for that purpose; and notice in writing of any proposed alteration shall be given to the Council, and read at the Ordinary Meeting, at least a month previous to the meeting at which such alteration is to be considered, and the proposed alteration shall also be printed in the Circular convening such meeting; but the Council shall have the power of enacting such Bye-laws as may be deemed necessary, which Bye-laws shall have the full power of Laws until the ensuing Annual Meeting, or a Special Meeting convened for their consideration.

BYE-LAW.

All nominations of Student Members shall be passed by the Council previous to nomination at an Ordinary Meeting. When elected, Student Members shall be entitled to all the privileges of Ordinary Members, except that they shall not receive the publications of the Society, nor vote at the Meetings, nor serve on the Council.

LIST OF MEMBERS

OF THE

LIVERPOOL BIOLOGICAL SOCIETY.

SESSION 1888–9.

A. Ordinary Members.

(Life Members are marked with an asterisk.)

ELECTED.

1888 Atkin, Hope T., Egerton House, Egerton Park, Rock Ferry.
1886 Banks, Prof. W. Mitchell, M.D., F.R.C.S., 28, Rodney-street.
1886 Bark, John, M.R.C.S., 42, Balliol-road, Bootle.
1886 Barron, Prof. Alexander, M.B., M.R.C.S., 31, Rodney-street.
1888 Beasley, Henry C., Prince Alfred-road, Wavertree.
1887 Caine, Nathaniel, 10, Orange-court, Castle-street.
1886 Capon, Robert M., L.D.S., Rodney-street.
1886 Caton, Prof. R., M.D., F.R.C.P., 18, Croxteth-road.
1886 Chisholm, J. M., M.D., White House, Woolton.
1886 Collins, A. W., M.B., 7, Rodney-street.
1886 Craig, Robert, 7, Clarendon-road, Garston.
1886 Dillcock, T., 8, Church-street, Egremont.
1886 Drysdale, John, M.D., President, 36A, Rodney-street.
1886 Edmonds, William, 69, Albany, Oldhall-street.
1886 Ellis, J. W., L.R.C.P., F.E.S., 3, Brougham-terrace.
1887 Gasking, Rev. S., B.A., F.G.S., 77, Ling-street, Edge-lane.
1886 Glynn, Prof., M.D., F.R.C.P., 62, Rodney-street.
1886 Gibson, R. J. Harvey, M.A., F.R.S.E., Botanical Laboratory, University College.
1886 Gatehouse, C., 74, Bidston-road, Birkenhead.
1888 Gutridge, Henry, 102, Hartington-road.
1886 Halhed, W. B., Sunnyside, Prince's Park.

ELECTED.

1886 Halls, W. J., 35, Lord-street.
1887 Hanitsch, R., Ph.D., Zoological Laboratory, University College
1887 Healey, George F., Oakfield, Gateacre.
1886 Herdman, Prof. W. A., D.Sc., F.L.S., F.R.S.E., Vice-President, University College.
1887 Hewitt. W., B.Sc., 16, Clarence-road, Birkenhead.
1887 Higgin, T., F.L.S, Ethersall, Roby.
1887 Hill, G. J., 23, Selborne-street.
1888 Hurst, C. H, Owens College, Manchester.
1886 Jones, Charles W., Field House, Prince Alfred-road, Wavertree.
1886 Larkin, F. C., M.R.C.S., Secretary, 29, Bedford-street North, or Physiological Laboratory, University College.
1886 Leicester, Alfred, 24, Aughton-road, Birkdale.
1886 Lomas, J., Assoc. N.S.S., 23, Selborne-street.
1888 Melly, W. R., 90, Chatham-street.
1886 McMillan, William S., F.L.S., Brook-road, Maghull.
1886 McClelland, Joseph, M.D., 7, Sefton-drive, Sefton Park.
1886 Moore, Thomas J., C.M.Z.S., Free Museum
1886 Moore, G. F., 15, Kremlin-drive, Tuebrook.
1886 Morton, G. H., F.G.S., 209, Edge-lane, E.
1887 Narramore, W., 5, Geneva-road, Elm Park.
1888 Phillips, Reg. W., B.A., University College, Bangor.
1886 *Poole, Sir James, J.P., Vice-President, Abercromby-square.
1886 Rathbone, Theodore, F.L.S., Backwood, Neston.
1886 Read, William H., 6, Dingle-lane.
1886 Roberts, I., F.G.S., Kennessee, Maghull.
1887 Robertson, Helenus R., Glendaragh, Livingstone-drive.
1887 Ryley, Thomas C., 31, Alexandra-drive.
1886 Smith, Andrew T., Jun., 13, Bentley-road, Prince's Park.
1886 Tate, A. Norman, F.I.C., 9, Hackins-hey.
1886 Thompson, Isaac C., F.L.S., F.R.M.S., Treasurer, Woodstock, Waverley-road.
1886 Vicars, John, 8, St. Albans-square, Bootle.
1886 Walker, Alfred O., J.P., F.L.S., Leadworks, Chester.
1886 Walker, George, F.R.C.S., 43, Rodney-street.

B. Student Members.

Armstrong, Miss A., 26, Trinity-road, Bootle.
Baylis, W. J , 56, Vine-street.
Bell, R. G., 8, George's-hill.
Bell, W., 5, Dryden-road, Edge-lane.
Brown, Miss M., Dingle Priory, Dingle.
Browne, H. J. M., 39, Rodney-street.
Buckley, Miss L., Mildmay House, Blackburne-place, Hope-street.
Chalmers, A. J., West Bank, Waterloo-road, Waterloo.
Clapham, G. P. P., 13, Ducie-street.
Clubb, J. A., Zoological Laboratory, University College.
Conroy, J. T., 10, Radnor-place, Tuebrook.
Davies, Benjamin, Physical Laboratory, University College.
Dickinson, Thomas, 3, Clarke-street.
Earnshaw, W. H., Leavy Greave, Rudgrave-place, Egremont.
Edgecombe, W., Uplands, Blundellsands.
Evans, John, 7, Elm Bank, Walton Breck-road, Anfield.
Fowler, Miss C., High School, Belvidere-road.
Gould, Joseph, Littledale-road, Egremont.
Hannah, J. H. W., 4, Adderley-street, Edge-lane.
Harding, Miss M., Kremlin-drive, West Derby.
Hornell, James, 105A, Grove-street.
Hughes, W. Rathbone, 3, Prince's-gate, Prince's Park.
Jones, C. R., St. John's Vicarage, Waterloo.
Jones, Miss M., Summerhill House, Litherland.
Lomas, Mrs. J., 23, Selborne-street.
McLachlan, Robert, 28, Ruby-street, Dingle.
McMillan, R., 34, Salisbury-street.
Moore, E., 16, Queen's-road, Southport.
Nixon, J. P., 40, Spellow-lane, Kirkdale.
Noble, Miss Jessie, 6, Prince's-avenue.
O'Brien, Miss Mary, 47, Kingsley-road
Palethorpe, Miss F., 85, Gladstone-road, Edgehill.
Partridge, A. J., 25, Seacombe Villas, Seacombe.
Peters, T J., 10, Brookland-street, Stoneycroft.

Porter, A. W., 37, Ridley-street, Birkenhead.
Putt, D. F., 43, Grey-road, Walton.
Quehen, E., Argo-road, Waterloo.
Robinson, H., Physical Laboratory, University College.
Rowlands, W. Ellison, 28, Green-lane, Stoneycroft.
Schröder, Miss K., High School, Belvidere-road.
Schweizer, W., 2, Ashfield, Wavertree.
Small, Laurence, 71, Geraint-street.
Spencer, Edward, 36, St. James's-road,
Sykes, S. I, 5, Adelaide-road, Seaforth.
Tarbet, W. E., 8, Gambier-terrace.
Tarleton, Thomas, 1, Hyde-road, Waterloo.
Thompson, D. W. M., 19, St. Domingo-vale.
Wells, Miss C., 46, Berkley-street.
Williams, Henry, Jun., 57, Balliol-road, Bootle.

C. Honorary Members.

H.M. King Kalakao, the Palace, Honolulu, Sandwich Islands.
Marshall, Prof. A. Milnes, D.Sc., M.D., F.R.S., Owens College, Manchester.

THE LIVERPOOL BIOLOGICAL SOCIETY,

Dr. IN ACCOUNT WITH ISAAC C. THOMPSON, HON. TREASURER. Cr.

1888.	£	s.	d.
To Use of Rooms, University College	3	0	0
,, Tea and Attendance at Meetings	4	14	5
,, Printing and Stationery, Turner, Routledge & Co.	36	6	6
,, Do. Dobbs, Thos. & Co.	2	5	6
,, Do. Parker & Coward	16	2	0
,, Advertising, "Nature"	0	7	6
,, Postages, per Secretary	3	11	6
,, Do. Treasurer	1	0	0
,, Balance in hand 30th Sept., 1888	66	1	11
	£133	9	4

1888.	£	s.	d.
By Balance, 30th Sept., 1887	61	12	10
,, 7 Members' Entrance Fees at 10s 6d	3	13	6
,, 16 Student Members' Entrance Fees at 2s 6d	2	0	0
,, 53 Members' Subscriptions at 21s	55	13	0
,, 40 Student Members' Subscriptions at 5s	10	0	0
,, Sale of 2 copies Proceedings, Vol. I.	0	10	0
	£133	9	4
By Balance in hands of Treasurer	£66	1	11

ISAAC C. THOMPSON,
HON. TREASURER.

LIVERPOOL, 30*th September*, 1888.

Audited and found correct,
ALFRED LEICESTER.
J. LOMAS.

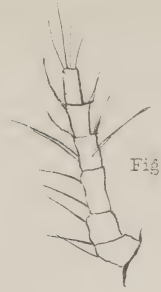


Fig. 2.

Fig. 1

Fig. 7.

Fig. 3.

Fig. 8.

Fig. 6.

Fig. 4.

Fig. 9.

Fig. 5.

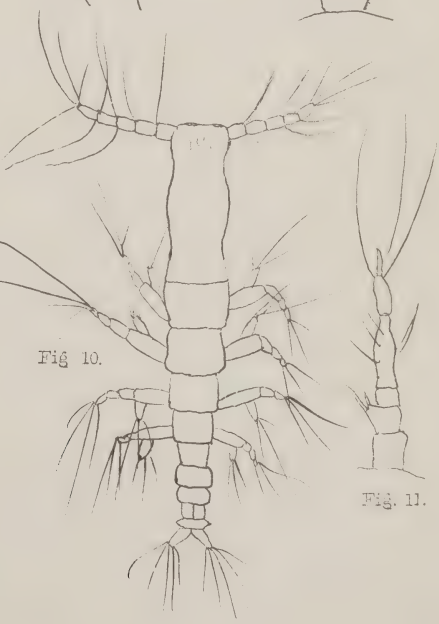


Fig 10.

Fig. 11.

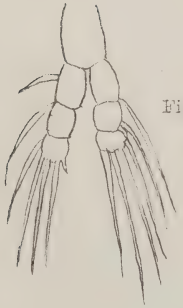


Fig. 12.

I. C. Thompson, del.

CYCLOPS PUFFINI, n. sp. Figs. 1--9.
CYMBASOMA HERDMANI, n. sp. Figs. 10—12.

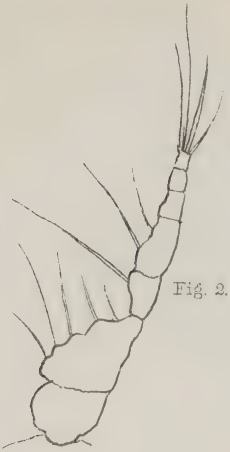


Fig. 2.

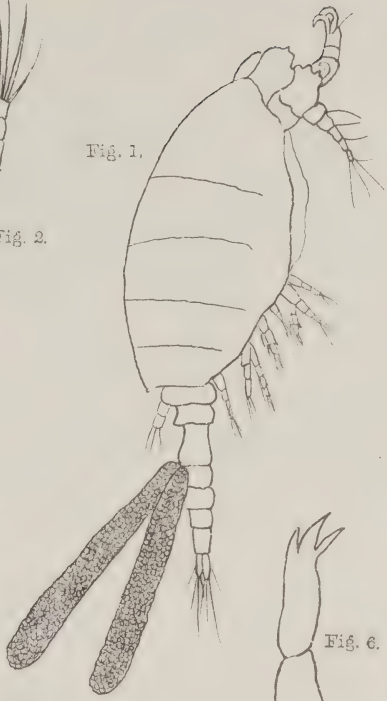


Fig. 1.

Fig. 3.

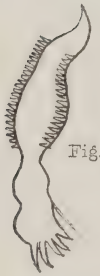


Fig. 4.

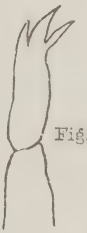


Fig. 6.

Fig. 5.

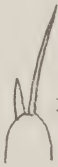


Fig 9.

Fig 7.

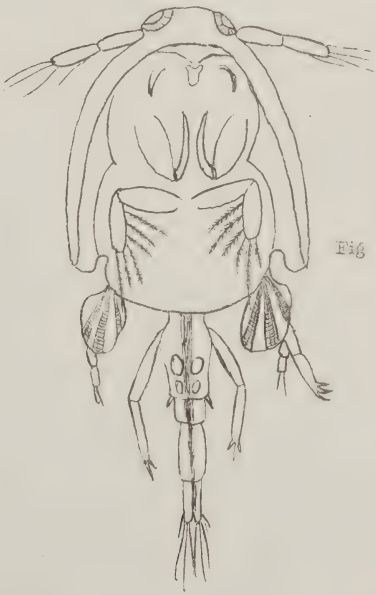


Fig 10.

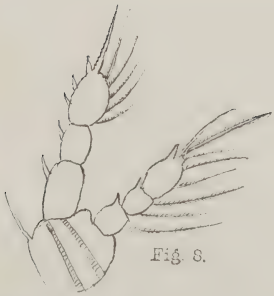


Fig 8.

I. C. Thompson, del.

LICHOMOLGUS SABELLÆ n. sp. Figs 1 – 9.
TREBIUS CAUDATUS, Kroyer, Fig. 10.

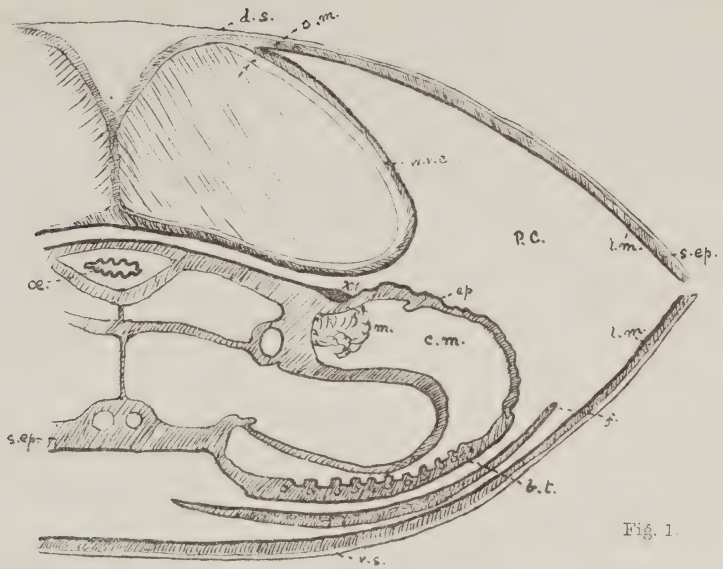


Fig. 1.

Fig. 2.

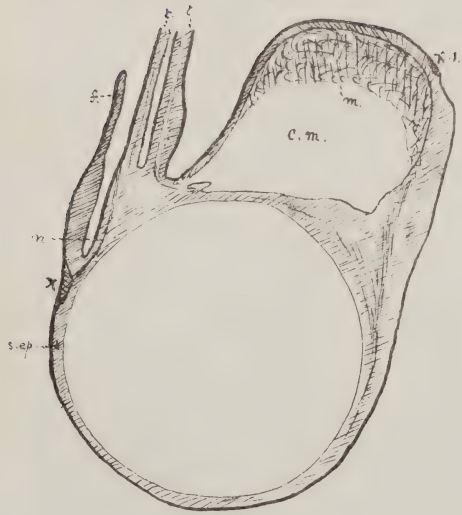
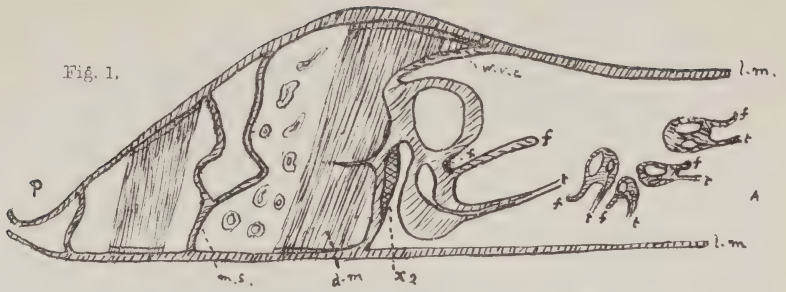


Fig. 3.

A. Heath, del.

Figs. 1 & 2, LINGULA. Fig. 3, CRANIA.

Fig. 1.



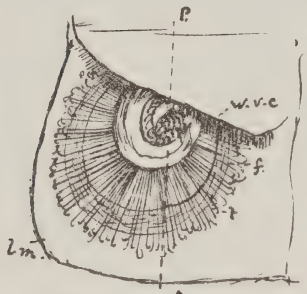


Fig. 2.

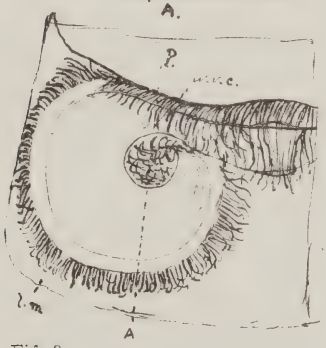


Fig. 3.

Fig. 4.

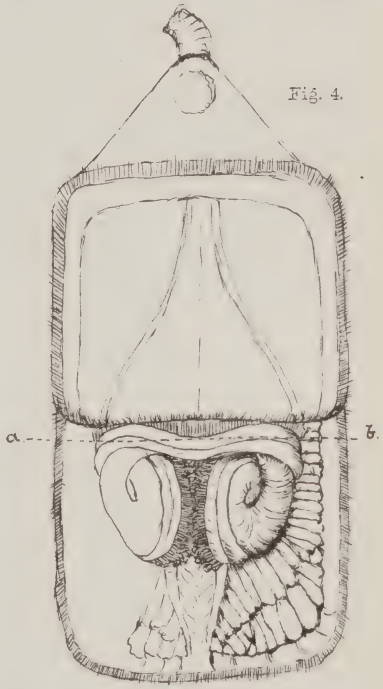
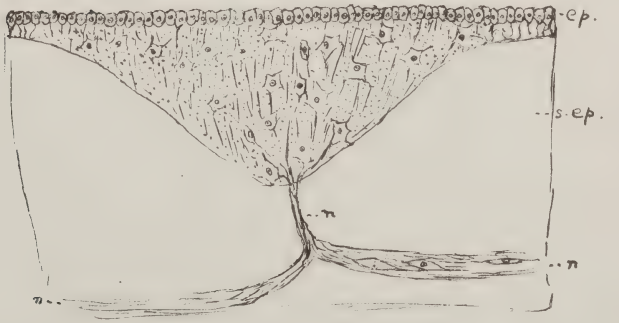


Fig. 5.



A. Heath, del.

Figs. 1, 2, 3 & 5. CRANIA. Fig. 4. LINGULA.

Fig. 1.

Fig. 2.

Fig. 3.

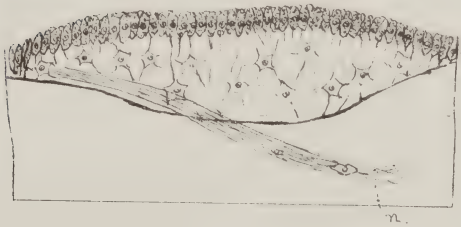


Fig. 4.

A. Heath. del.

Figs. 1, 2, 3, LINGULA. Fig. 4, CRANIA.

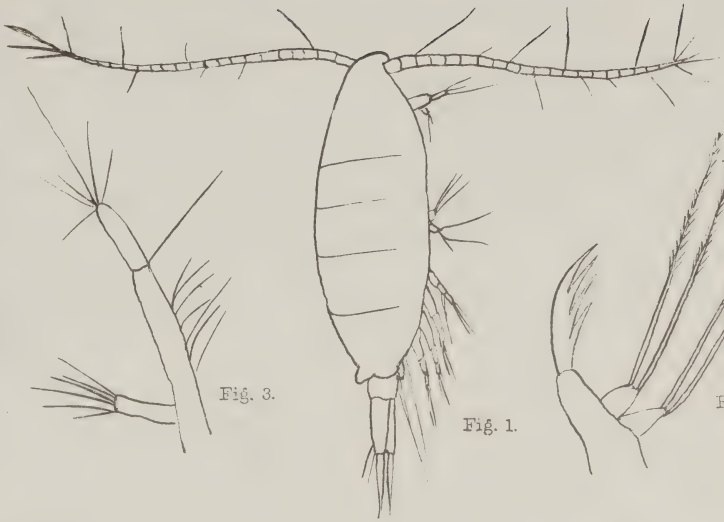
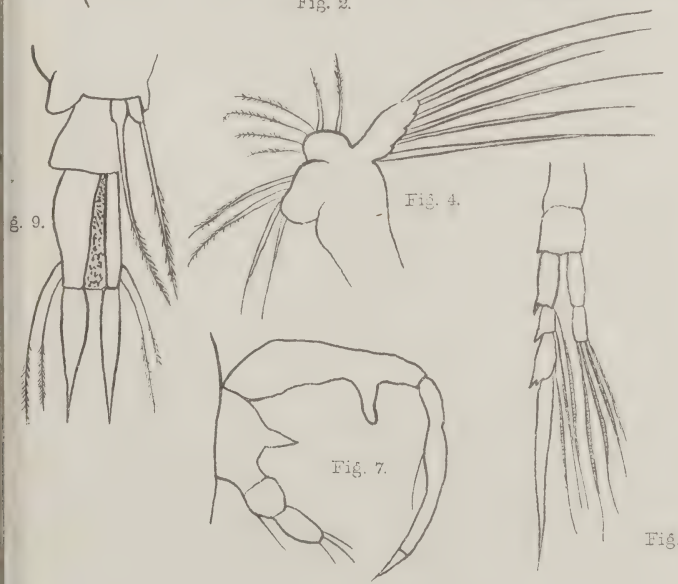


Fig. 3.

Fig. 1.

Fig. 5.

Fig. 2.



g. 9.

Fig. 4.

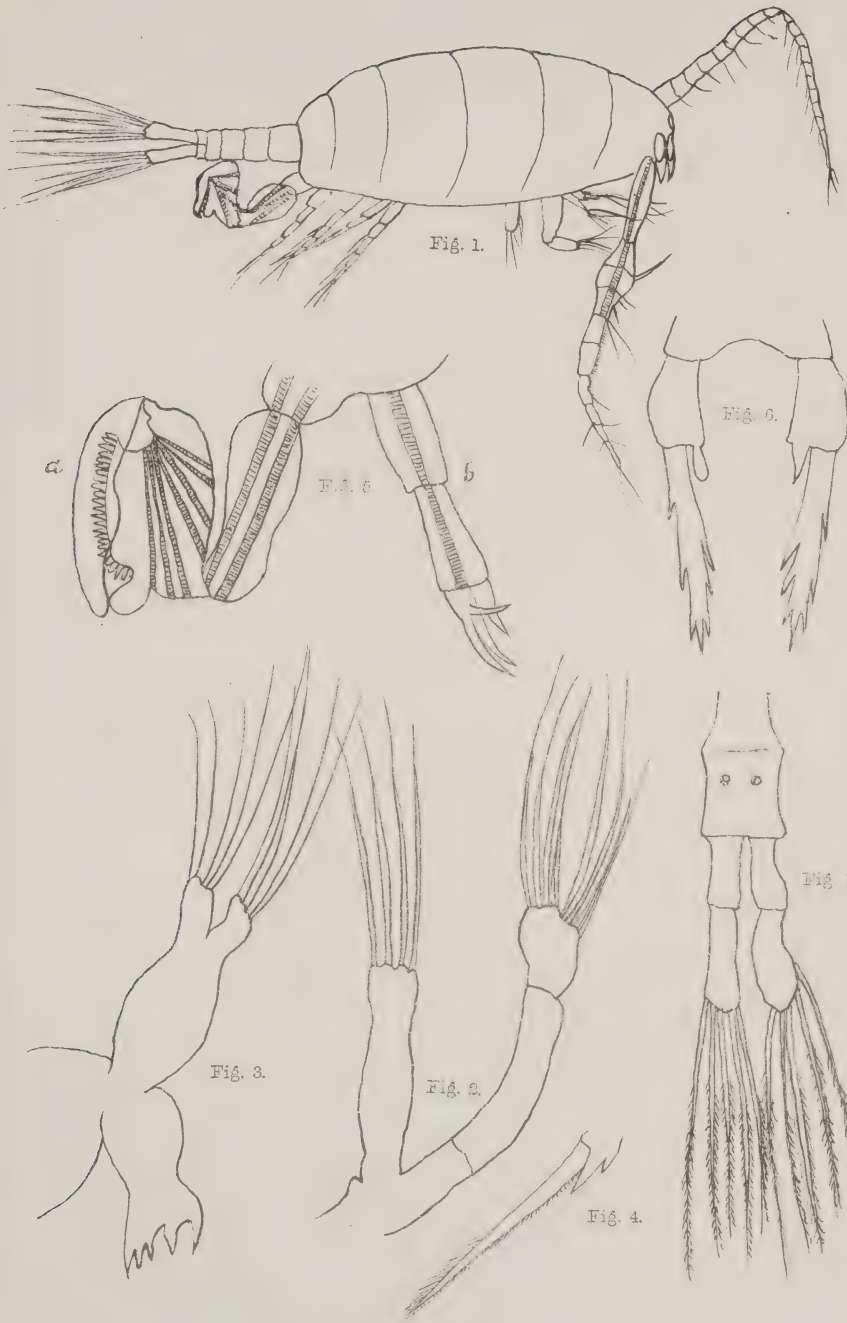
Fig. 7.

Fig. 6.

Fig. 8.

I. C. Thompson, del.

ACARTIA VERRUCOSA, n. sp. Figs. 1 — 9.



I. C. Thompson, del.

PONTELLA MEDITERRANEA, Claus. Figs. 1 — 7.

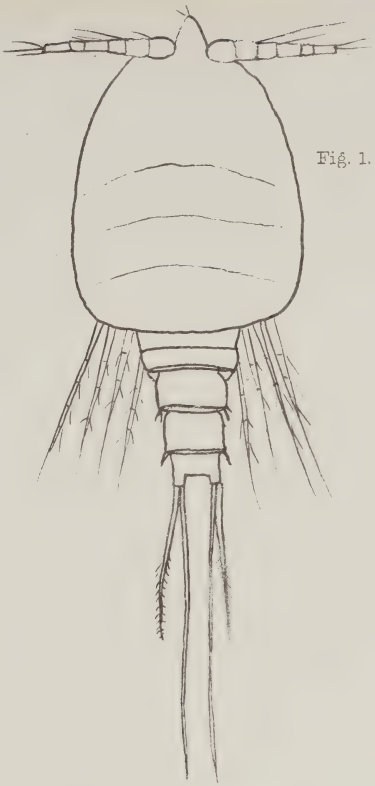


Fig. 1.

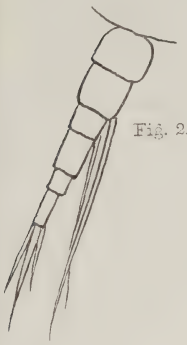


Fig. 2.

Fig. 5.

Fig. 3.

Fig. 7.

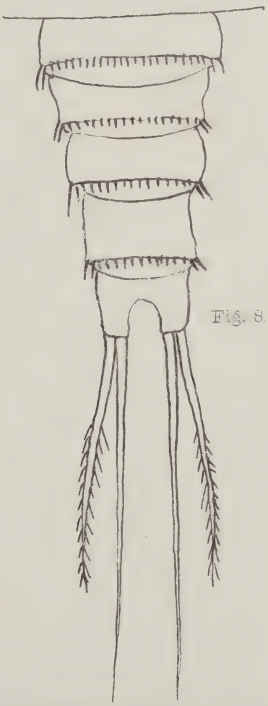


Fig. 8.

Fig. 6.

Fig. 4.

I. C. Thompson, del.

ZOSIME RUBRA, n. sp. Figs. 1—8.

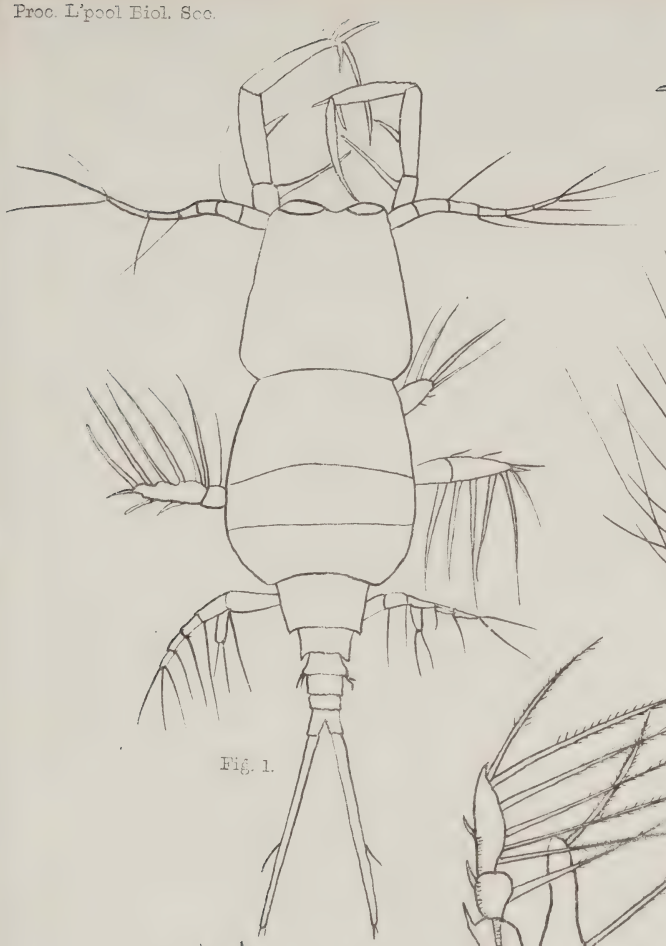


Fig. 1.

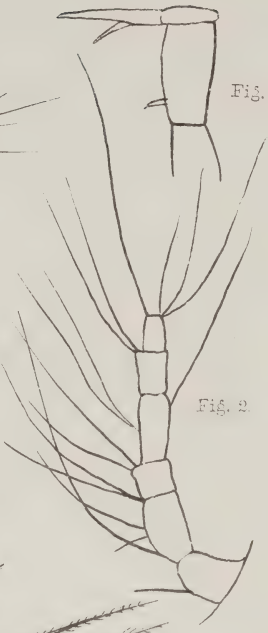
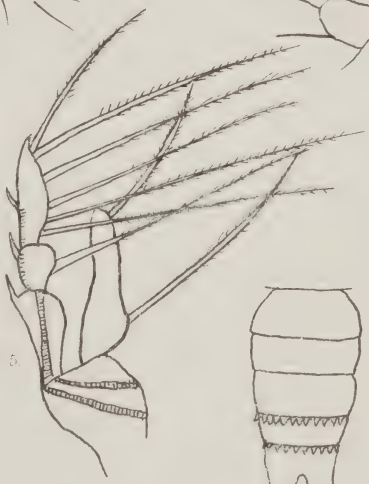


Fig. 2.

Fig. 3.



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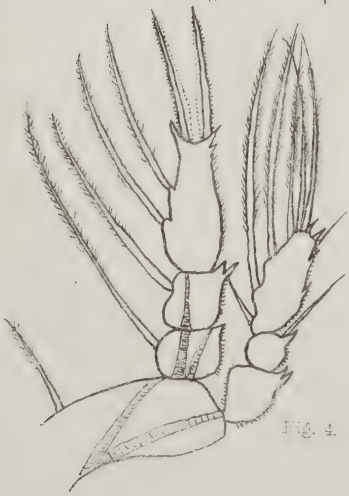


Fig. 4.

Fig. 6.

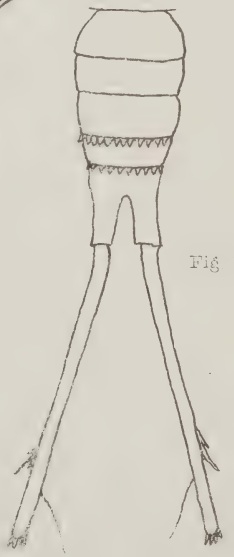


Fig. 7.

I. C. Thompson del.

COPILIA BRUCII, n. sp. Figs. 1 – 7.

Fig. 1.

Fig. 2.

Fig. 3.

R. Hanitsch, del.

LIMAX AGRESTIS.

Fig. 1.

R. Hanitsch, del.

Fig. 2.

LIMAX AGRESTIS.

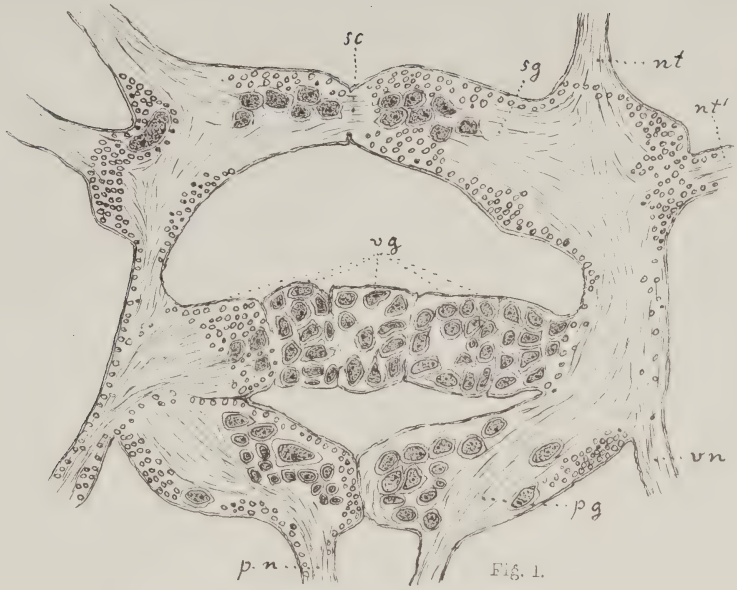


Fig. 1.

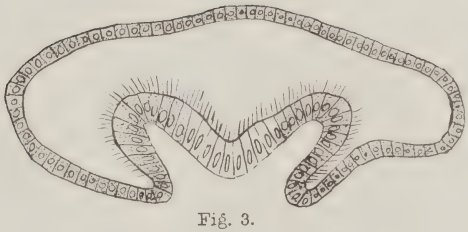


Fig. 3.

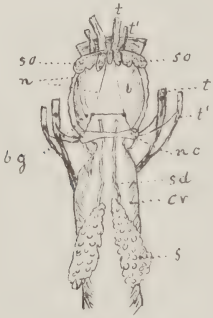


Fig. 2.

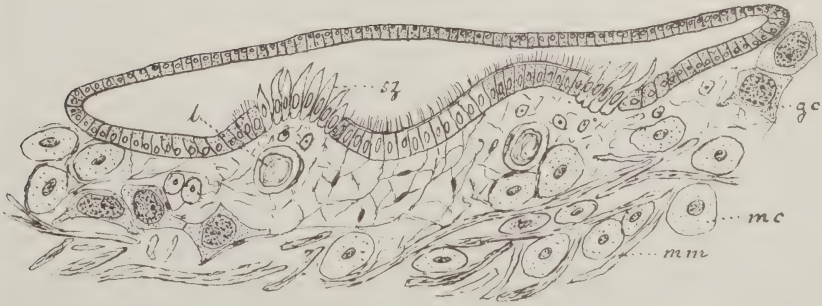
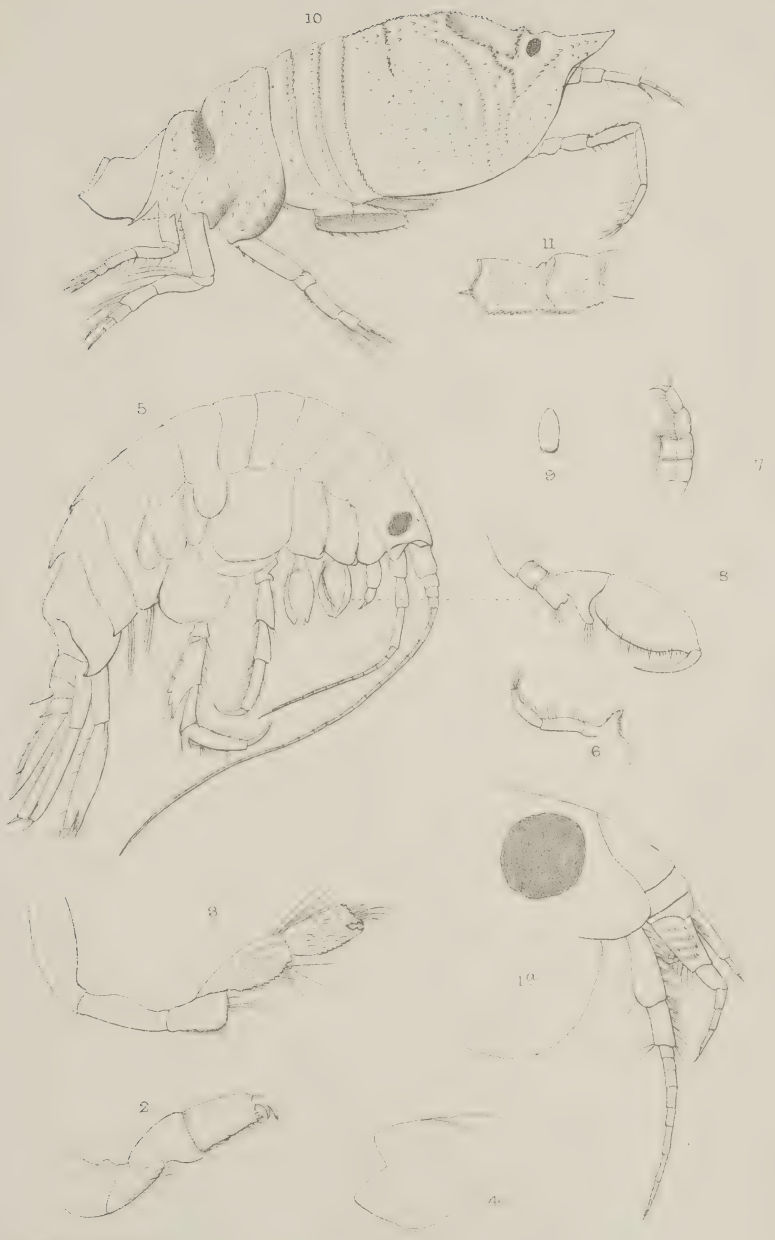


Fig. 4.

R. Hanitsch, del.

LIMAX AGRESTIS.



Alfred O. Walker del.
Parker & Coward lith.

West, Newman & Co imp.

TRYPHOSA CILIATA (Sars), Fig. 1-4
PLEUSTES BICUSPIS (Kröyer) „ 5-9
DIASTYLIS BRADYI (Norman) „ 10-11

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